1. TASK

This feasibility study addresses the anticipated changes in the high-voltage electrical system of the existing building of the ELI International Laser Research Center in Dolní Břežany.

The center consists of the following buildings:

- SO 01 (also Building A) – Administrative and multifunctional building connected by an entrance atrium,
  - OF – Office building
  - MF – Multifunctional building
  - AT – Entrance atrium
- SO 02 (also Building B) – Laser building with laboratories,
  - LB – Laboratory building (Laboratories)
  - LH – Laser Hall
- SO 03 (also Building C) – Technical gas management and cooling technology.
  - CO – Cooling technology (Central cooling)
  - TG – Technical gases management (also source station)

The anticipated changes and modifications concern the following topics:

- Strengthening the electrical supply for floor S SO 02 (3rd floor LH)
- Stabilization of power supply for building SO 02 (primarily L and E floors – 2nd basement and 1st floor LH) – the aim is to eliminate the impact of poor network quality on scientific equipment
- Connection of the planned photovoltaic power plant to the existing building electrical installation

1.1. Project documentation

- Project documentation of the actual construction
- Investor requirements
- Documents from existing UPS sources
- Documents from secondary measurements of individual outlets from main distribution boards
- Other documentation provided by the investor
- Inspection of the building
- Valid regulations and ČSN standards

2. BASIC TECHNICAL DATA

Power source:

- 3x 22/0.4 kV transformer, 2000 kVA – SO01, SO02
- 1x 22/0.4 kV transformer, 1600 kVA – SO03 Backup

power source:

- 1× diesel generator in a container, size: 1650kVA

Uninterruptible power supply:

- 1× UPS with a capacity of 2x 250kVA in redundant operation
- 1x UPS with a capacity of 2x 300kVA in parallel operation
- 1x UPS with a capacity of 1x

80kVA Current system, voltage:

- 3NPE, 230/400V, 50Hz, TN-C-S (low-voltage distribution boards)
- 3PEN, 230/400V, 50Hz, TN-C-S (main switchboards of buildings)
- 3NPE, 230/400V, 50Hz, TN-S (secondary switchboards, electrical installations)
- 24V DC, IT – KNX system, DALI

Electricity consumption measurement:

- on the HV side, USM measurement cabinet located in the LV substation (1st floor of the LB building) for all four transformers

Short-circuit and overload protection: by safety devices in switchboards

Protection against dangerous touch voltage (according to ČSN 332000-4-41 ed.2 incl. Z1):

normal: automatic disconnection from the source

supplemented: by residual current devices and protective bonding

3. DESCRIPTION OF THE OBJECT

The international laser center complex consists of the SO02 laser center building (Building B), which houses the laser technology facilities known as the laser hall, and the laboratory facilities known as the LAB building. The building has four above-ground floors and two underground floors, with a height of 10.5 m. The laser hall houses experimental facilities on the second and first basement floors, while the above-ground floors house laser technology facilities. The LAB building houses laboratories, technical rooms, an engine room, and a fire protection tank on the second basement floor, while the first basement floor houses the building's energy center (low-voltage switchboard, transformer station, fire equipment switchboard, and uninterruptible power supply), server room, workshops, and laboratories. The first above-ground floor houses laser beam control rooms, laboratories, workshops, and offices, while the other above-ground floors house laboratories, workshops, and offices. The building also houses social and technical facilities, including a freight elevator.

Building SO01 (Building A), divided into two buildings, offices designated as office space and a multifunctional building connected by an atrium, has three above-ground floors, with a fire height of 7.2 m above ground level. The office building has offices, meeting rooms, a server room, accessories, and a hall (atrium) on the first floor, and offices and meeting rooms with accessories on the second and third floors. The fourth floor is exclusively a technical floor, where the air conditioning machine room for the office building is located. There is one passenger elevator in the building and two more in the atrium.

The multifunctional building has a dining room with a kitchen and facilities (open space, electrical installation to be built by the tenant), security offices and facilities, a room for charging the platform, and a garbage room on the first floor. The second floor of the dining room, lounges, classroom, audiovisual room (lecture hall), and accessories are located on the second floor, and a library, office, meeting room, accessories, and ventilation machine room for the multifunctional building are located on the third floor. There is one passenger elevator in the building.

On the southern part of the property, under the laser hall, there is a separate central cooling machine room and a separate technical gas storage facility marked as SO03. The buildings are single-story. The gas storage facility is designed with only an electricity supply; all equipment, including internal electrical wiring, is part of the storage technology delivery.

4. CURRENT STATUS

4.1. <u>LV substation (S network)</u>

The LV switchboard is located on the first basement floor of the LAB building in a separate room. The switchboard houses the main switchboards of the building, which are powered from the grid (*RH1* – powers buildings SO01 and SO02 – LB and LH only corridors, staircases, and technical rooms, *RH2* – SO02 laser hall LH – complete experimental technology including vacuum pumps, *RH3* – complete HVAC technology including the MaR system, freight elevator SO02 and consumption of the D network of the entire center) and a backup power source (*RH/DA)* and secondary switchboards for other equipment.

For the central cooling machine room and gas storage facility SO03, the main switchboard for the facility, powered from the grid and the DA backup power source (*RH03 and RH03/DA*), is located in the central cooling machine room.

Current maximum power consumption from the grid for individual transformers via main switchboards (data taken from the investor's documentation on measurements by the electricity distributor and from network analyzers installed at the inputs to the main switchboards of the transformer supply lines, equipped with secondary electricity meters in the main switchboards):

RH1 – transformer *T1* – 441kW *RH2* – transformer *T2* – 505kW *RH3* – transformer *T3* – 822kW

4.2. *Backup power source – diesel generator (network D)*

A backup power source – diesel generator – is installed to back up the operation of important and firefighting equipment in the building. The diesel generator is a compact container unit installed outdoors next to the Laser Hall building with a capacity of 1650 kVA.

The backup power source backs up the operation of important equipment and appliances in the building:

- firefighting equipment (as required by the fire report)
- emergency and backup lighting (common areas, corridors, machine rooms, etc.),
- low-voltage switchboards and equipment,
- HVAC technology (clean room ventilation, plumbing, cooling systems, etc.),
- uninterruptible power supplies (UPS),
- sprinklers,
- other

The total simultaneous power consumption supplied by the diesel generator was calculated in the implementation project documentation to the following values:

- during a power failure 1070.1 kW (at full load of existing UPS sources)
- in case of fire 136.4 kW

4.3. *Uninterruptible power supplies – UPS (network U)*

To ensure uninterrupted power supply, three uninterruptible power supplies (UPS) are installed in a separate room in the SO 02 LAB building on the first basement floor. UPS 1 with a capacity of 2x 250kVA/225 kW in redundant operation with a backup time of 5 minutes, UPS 2 with an output of 2x 300kVA/270kW with a backup time of 5 minutes (equipped with batteries for an output of 270kW with the possibility of expansion and addition of batteries for a full output of 540kW), UPS 3 with an output of 80kVA/72 kW with a backup time of 5 minutes.

UPS 1 is used for continuous power supply to server rooms – the main server room on the 1st basement floor of the LAB building and the secondary server room on the 1st floor of the office building. Two identical UPS sources are installed and connected in redundant operation. This connection ensures that even in the event of a failure of one of the UPS units, the load is still 100% backed up by the second unit. The consumption from these UPS units is supplied via the main UPS1 *RUPS1* switchboard. UPS 2 is used to ensure uninterrupted power supply to selected technological equipment in the SO 02 – laser hall. The two sources are in parallel operation, the batteries are currently set to half power (50%), i.e., the power of only one source (270 kW) with space reserved for the delivery of batteries for the second source. The consumption from these UPS sources is supplied via the main UPS2 *RUPS2* power distribution board.

UPS 3 is used to power sockets at each workstation in the SO01 office building. Consumption from this UPS source is powered via the main UPS3 *RUPS3* switchboard.

The uninterruptible UPS power supplies are powered from the network backed up by a diesel generator via the *RH/DA* switchboard, and each UPS power supply has a separate switchboard from which the switchboards requiring power from the uninterruptible network are connected to the relevant UPS power supplies.

The current maximum power consumption from individual UPS units is taken from the investor's documentation from the service reports of individual backup units carried out in December 2020:

UPS1 – 27.7 kW
UPS2 – 36 kW *UPS3*
– 17.3 kW

5. DESCRIPTION OF THE TECHNICAL SOLUTION

5.1. Reinforcement of the electrical supply for floor S SO 02 (3rd floor LH)

5.1.1. *Power supply*

One LUIS laboratory has been built in the free space for support technologies on the 3rd floor of the laser hall, and the investor wants to build additional laboratories in this space.

The existing LUIS laboratory is powered from the existing switchboard located in the RI.20.012 support technology space from a network with an installed power consumption of 28kW and a simultaneous power consumption of 19kW.

According to the submitted implementation project for these laboratories, the newly planned ELILab S2 laboratories will require a total installed power consumption of 258.9 kW from the network and a simultaneous power consumption of 158.5 kW for all equipment and technologies. At the same time, there is a requirement to connect the laboratories to a backup source from network D, with a total installed power consumption of 99.2 kW and a simultaneous power consumption of 85.4 kW (this includes the connection of a new UPS backup source for the laboratory with a power of 53 kW).

New power supplies will be installed for these laboratories and any others that may be planned in the future, taking into account the available space for support technologies on the 3rd floor, both from the S network and from the DA backup source, D network.

Estimated energy balance:

	S network Pi (kW)	D network Pi (kW)	Simultaneity	Network S Ps (kW)	Network D Ps (kW)
LUIS laboratory	2		0.68	1	
ELILab S2 laboratories	258.9	99.2		158.5	85.4
Reserve for other laboratories	300	50	0.7	210	35
Total	586.9	149.2		**387.5**	**120.4**

The planned power consumption would be best connected to the least loaded transformer *T1*, according to the above-mentioned maximum current power consumption drawn from *T1*.

The considered power input to network D, backed up by a diesel generator, is the maximum that can be additionally connected to the generator, taking into account the current load of DA!

To ensure uninterrupted power supply to technological equipment, local UPS sources with batteries will be installed in the northern ventilation machine room, powered from network S, not from the backup network D backed up by a diesel generator, depending on the required backup time!

5.1.2. Modifications to the existing electrical installation

Given the limited space in the LV substation and the location of the *RH1* switchboard in the LV substation, the most suitable option appears to be to add to the free space in the fifth field (including the need to modify this field, move the existing circuit breakers in the field connected by cables to the busbars so that a new circuit breaker can be installed in the free space) of the main *RH1* switchboard with a rated current of 630A, to which it would be possible to connect the considered maximum power consumption from the 387.5kW network. Together with the circuit breaker, a measurement of the electrical energy consumed by the outlet connected to the existing system for measuring the electrical energy consumption of some outlets from the main LV switchboards will be added.

With regard to the layout of the *RH/DA* switchboard, a branch circuit breaker with a rated current of 250A would be added to the 4th pole of the existing switchboard, with the trip set to the maximum short-circuit trip current of 190A, taking into account the maximum power of 120kW. The outlet would be equipped with a contactor for gradual connection of loads to the DA (delay from DA start-up 35s) with regard to the gradual loading of the unit in the event of a power failure to prevent its overload.

5.1.3. Switchboards

To power the electrical installation of the existing laboratory and the planned laboratories, a main switchboard for powering the laboratories would be located in the northern ventilation machine room, divided into a mains section S and a backup section D, from which the switchboards installed as part of the delivery of the individual laboratories will be powered.

The switchboard will contain an input panel with a main switch for the S network input, an input and output panel for the D backup network, 2nd degree surge protection on both inputs, and an output panel for powering the individual secondary switchboards of the laboratories, including any secondary measurement of the electricity consumption of the individual laboratories from the S network.

5.1.4. Cable routes

Cable routes will be made of copper all-plastic conductors with separate working and protective neutral conductors in fire-retardant CXKH-R, B2 s1 d0 design. Existing cable routes in the LV substation will be used to the maximum extent possible. The main riser cable route from the LV substation on the 1st floor to the 3rd floor of the LH laser hall building will be routed along the existing riser route in the LB laboratory building at the level of the HVAC machine room. Alternatively, it would be possible to use the main riser route for the 3rd and 4th floors of LH located in the middle of the wall between LB and LH. This main riser runs from the 1st basement floor to the 3rd floor of LB and passes through the 3rd floor into the LH building, where it rises under the ceiling of the 4th floor and passes into the northern HVAC machine room. A cable tray for new cables would have to be added in the passage under the ceiling of the 4th floor.

Both risers are inaccessible and walled up in some areas, or located in suspended ceilings, so the installation of new cables would require construction work on the building (demolition, bricklaying, plaster repairs, painting, etc.).

The installation of new cable lines as described would be carried out together with the cables according to paragraph 5.3. Where routes pass between fire compartments, the penetrations will be sealed with fire seals or sealing compound, e.g., INTUMEX.

5.2. Power supply stabilization for building SO 02 (primarily L and E floors – 2nd basement and 1st floor LH)

5.2.1. <u>Electricity supply – existing</u>

The existing experimental hall spaces E1 to E6 located on the 2nd basement floor of building LH are powered via the experimental hall switchboards: E1 – *RI.02.010*, E2 – *RI.02.020*, E3 – *RI.02.030*, E4 – *RI.02.040*, E5 – *RI.02.050* and E6 – *RI.02.060*, and the laser technology space L4c on the 2nd basement floor of LH via switchboard *RI.02.070*.

The existing laser technology rooms L1 to L3 and L4b located on the 1st floor of the LH building are powered via switchboards: L1 – *RI.00.010*, L2 – *RI.00.020*, L3 – *RI.00.030* and L4b – *RI.00.040*.

The existing laser technology rooms located on the 2nd floor of the LH building are powered by switchboards *RI.20.010* – support systems, *RI.20.020* – technology – capacitors, and *RI.20.030* – laser technology L4a.

All of the above switchboards are supplied from the S network from the main switchboard *RH2* (transformer T2), 4th – 6th pole of the switchboard (6 poles in total) and the fail-safe network U from the main switchboard of the UPS *RUPS2* source, backed up by UPS2.

Energy balance – current:

	S network Pi (kW)	U network Pi (kW)	Simultaneity	Network S Ps (kW)	Network U Ps (kW)
E1 – RI.02.010	131.1	30	1	23.7	30
E2 – RI.02.020	129.7	30	1	21	30
E3 – RI.02.030	126.3	30	1	23.7	30
E4 – RI.02.040	200	50	1	28.2	50
E5 – RI.02.050	195.2	55	1	26.1	55
E6 – RI.02.060	186.3	55	1	3.4	55
L4c – RI.02.070	195	55	1	21.8	55
L1 – RI.00.010	404.6	40	1	33	40
L2 – RI.00.020	221.4	40	1	15.7	40
L3 – RI.00.030	186.4	40	1	20.8	40
L4b – RI.00.040	164.6	25	1	49.8	25
Other laser technology rooms on the 2nd floor	1019.1	80	1	112.6	80
Total	2140.6	530		**379.8**	**530**

Note

The current installed power ratings are the values specified in the building's implementation project documentation from August 2012.

The simultaneous power consumption supplied from the S network is based on data from the installed electricity consumption meters on individual outlets for secondary switchboards from the main *RH2* switchboard for the last year of operation from 05/2020 to 05/2021.

The specified simultaneous power consumption of outlets supplied from the fail-safe network U backed up by the UPS2 source is the maximum considered and possible, and not the actual power consumption of the building.

5.2.2. Power supply in the event of modifications

Option A:

As part of the voltage stabilization of building SO02, primarily the experimental halls on the 2nd basement floor and laser technologies on the 1st floor, it is planned to reconnect the existing switchboards of the individual rooms powered from the S network to the existing uninterruptible power supply U powered from the existing UPS2 source, which consists of two parallel UPS sources, each with a power of 300 kVA.

Energy balance – after power supply stabilization:

	Current status			After stabilization	
	Network S Pi (kW)	Network S Ps (kW)	Network U Pi,Ps (kW)	Network S Ps (kW)	Network U Ps (kW)
E1 – RI.02.010	131.1	23.7	30	0	23.7
E2 – RI.02.020	129.7	21	30	0	21
E3 – RI.02.030	126.3	23.7	30	0	23.7
E4 – RI.02.040	200	28.2	50	0	28.2
E5 – RI.02.050	195.2	26.1	55	0	26.1
E6 – RI.02.060	186.3	3.4	55	0	3.4
L4c – RI.02.070	195	21.8	55	0	21.8
L1 – RI.00.010	404.6	33	40	0	33
L2 – RI.00.020	221.4	15.7	40	0	15.7
L3 – RI.00.030	186.4	20.8	40	0	20.8
L4b – RI.00.040	164.6	49.8	25	0	49.8
Other laser technology rooms on the 2nd floor	1019.1	112.6	80	112.6	0
Current consumption from UPS2					37
Total	3159.7	379.8	530	**112.6**	**304.2**

Note

The specified simultaneous power consumption of outlets powered from the uninterruptible power supply network U backed up by UPS2 are the values of the current measured consumption from the S network connected to the uninterruptible power supply network U

As can be seen from the energy balance after voltage stabilization, in the case of a complete switchover of existing consumption from the S network on the 2nd basement floor and 1st floor of the laser hall building to the existing UPS2 source, this can be done without any problems if batteries are added for 100% backup of both UPS2 sources, i.e. for a total power of 540 kW with a 5-minute backup.

<u>**In this case, the total maximum consumption in the specified areas is limited by the maximum output of the UPS2 540kW source, i.e. the maximum power input Ps=540kW, in the event of switching the complete output of the UPS2 source to the specified areas!**</u>

In the event of this switchover, the consumption from transformer T2 will be reduced by approx. 267 kW and, conversely, the consumption from transformer T3 will be increased by approx. 267 kW. This increase in consumption from transformer T3 to a total value of approx. 1089 kW will not cause any problems, as transformer T3 will only be loaded to 55% of its maximum power.

Option B:

As part of the voltage stabilization of building SO02, an option is being considered to stabilize the power supply only for laser technologies on the 1st floor by reconnecting the existing switchboards of individual rooms powered from the S network to the existing uninterruptible power supply network U powered from the existing UPS2 source, which consists of two parallel UPS sources, each with a capacity of 300 kVA.

Energy balance – after power stabilization:

	Current status			After stabilization	
	Network S Pi (kW)	Network S Ps (kW)	Network U Pi,Ps (kW)	Network S Ps (kW)	Network U Ps (kW)
E1 – RI.02.010	131.1	23.7	30	0	0
E2 – RI.02.020	129.7	21	30	0	0
E3 – RI.02.030	126.3	23.7	30	0	0
E4 – RI.02.040	200	28.2	50	0	0
E5 – RI.02.050	195.2	26.1	55	0	0
E6 – RI.02.060	186.3	3.4	55	0	0
L4c – RI.02.070	195	21.8	55	0	0
L1 – RI.00.010	404.6	33	40	0	33
L2 – RI.00.020	221.4	15.7	40	0	15.7
L3 – RI.00.030	186.4	20.8	40	0	20.8
L4b – RI.00.040	164.6	49.8	25	0	49.8
Other laser technology rooms on the 2nd floor	1019.1	112.6	80	112.6	0
Current consumption from UPS2					37
Total	3159.7	379.8	530	**112.6**	**156.3**

Note

The specified simultaneous power consumption of outlets powered from the uninterruptible power supply network U backed up by UPS2 are the values of the current measured consumption from the network S connected to the uninterruptible power supply network U.

As can be seen from the energy balance after voltage stabilization, in the case of switching only voltage stabilization-sensitive technology from existing consumption from the S network on the 1st floor of the laser hall building to the existing U network distribution in individual rooms to the UPS2 source, this can be done without any problems even if the batteries for 50% backup of both UPS2 sources are left in place, i.e. for a total power of 270 kW with a 5-minute backup.

<u>In this case, the total maximum consumption in the specified rooms could then be limited by the maximum power of the UPS2 source of 270 kW (in the case of adding batteries 540 kW), i.e. the maximum power input Ps = 270 kW (540 kW), in the case of switching the complete power of the UPS2 source to the specified rooms!</u> With regard to the existing power supply to other areas from UPS2, the power would be limited by a circuit breaker with a rated current of, for example, 800A (max. 450kW).

In the event of this switchover, the consumption from transformer T2 will be reduced by approx. 119 kW and, conversely, the consumption from transformer T3 will be increased by approx. 119 kW. This increase in consumption from transformer T3 to a total value of approx. 941 kW will not cause any problems, as transformer T3 will only be loaded to 47% of its maximum capacity.

Option C:

As part of the voltage stabilization of building SO02, primarily the experimental halls on the 2nd basement floor and laser technologies on the 1st floor, there is another option with maximum utilization of the existing U uninterruptible power supply inputs to individual switchboards, thus utilizing most of the maximum capacity of the existing UPS2 source without further demanding modifications and changes to the existing electrical installation. The main modifications in this option would involve reconnecting only those consumers that are susceptible to voltage stabilization in the switchboards of individual rooms and modifying and reconnecting only one switchboard.

Energy balance

	Current status			After stabilization	
	Network S Pi (kW)	**Network S Ps (kW)**	**Network U Pi (kW)**	**Network S Ps (kW) - estimate**	**Network U Ps (kW)**
E1 – RI.02.010	131.1	23.7	30	3	20.7
E2 – RI.02.020	129.7	21	30	3	18
E3 – RI.02.030	126.3	23.7	30	3	20.7
E4 – RI.02.040	200	28.2	50	3	25.2
E5 – RI.02.050	195.2	26.1	55	3	23.1
E6 – RI.02.060	186.3	3.4	55	3	0.4
L4c – RI.02.070	195	21.8	55	3	18.8
L1 – RI.00.010	404.6	33	40	1.5	31.5
L2 – RI.00.020	221.4	15.7	40	1.5	14.2
L3 – RI.00.030	186.4	20.8	40	1.5	19.3
L4b – RI.00.040	164.6	49.8	25	1.5	48.3
Other laser technology rooms on the 2nd floor	1019.1	112.6	40	112.6	40
Current consumption from UPS2					37
Total	3159.7	379.8	490	**139.6**	**317.2**

Note

The specified values of simultaneous power consumption Ps from the S network after power stabilization are only estimates of existing consumption, e.g., lighting, standard sockets, sludge pumps, etc., which would remain powered from the network even after reconnection.

As can be seen from the energy balance after voltage stabilization, in the case of a complete reconnection of existing consumption from network S in the 2nd basement and 1st floor of the laser hall building to the existing UPS2 source, this can be done without any problems if batteries are added for 100% backup of both UPS2 sources, i.e. for a total power of 540 kW with a 5-minute backup.

In this case, the maximum possible (installed) power consumption in individual rooms from the S network will be maintained, and the total maximum consumption in the specified rooms will not be limited by the maximum power of the UPS2 source!

In the event of this switchover, the consumption from transformer T2 will be reduced by approx. 141 kW and, conversely, the consumption from transformer T3 will be increased by approx. 141 kW. This increase in consumption from transformer T3 to a total value of approx. 963 kW will not cause any problems, as transformer T3 will only be loaded to 48% of its maximum power.

5.2.3. Modifications to the existing electrical installation

Option A:

In the event of a complete reconnection of the aforementioned premises from network S to the fail-safe network U of UPS2, it will be necessary to modify both the main *RH2* switchboard located in the LV substation and the main UPS2 *RUPS2* switchboard located in the UPS room.

In the UPS room, it would be necessary to install another new 3rd pole of this switchboard with a width of 600 mm (500 mm) behind the corner of the 2nd pole of the *RUPS2* switchboard, with a depth of 600 mm, identical in design to the existing one, with a four-pole circuit breaker with a rated current of 1250 A (full power transfer of UPS2) and its connection by cables at the top to the busbars of the 2nd pole of the existing *RUPS2* switchboard. The newly modified *RH2* switchboard in the LV substation would be connected to this 3rd pole by cable.

With regard to the installation of outlet circuit breakers for the switched-over switchboards in the 4th and 5th poles of the *RH2* switchboard (6 poles in total), it will be necessary to make fundamental modifications to the existing main LV switchboard *RH2*. In addition

A 7th panel with a width of 800 mm, depth of 600 mm, and maximum height of 1900 mm will be added to the 6th panel of the switchboard. It will be identical in design to the existing switchboard, and the side cover of the 6th panel of the switchboard will be removed.

the 7th panel will be connected to the existing switchboard to form a single unit. The 7th panel of the switchboard will be equipped with a four-pole circuit breaker with a rated current of 1250A connected to the existing busbars of the switchboard and a four-pole switch with a rated current of 1250A connected by a cable from the rear of the switchboard to the UPS2 *RUPS2* uninterruptible power supply. The circuit breaker and switch will be mechanically interlocked to prevent simultaneous switching with manual control for manual manipulation of the connection of the specified loads to the S network or the UPS2 RUPS2 uninterruptible power supply. Both elements will be equipped with status signaling to the existing MaR system of the building in accordance with the building standard. The outputs of both elements will be connected together to new busbars with a rated current of 1250A installed in the lower part of the new 7th field of the switchboard and extended to the existing 4th - 6th fields of the switchboard above the main existing busbars of the *RH2* switchboard.

The existing circuit breakers FA4.3 to FA4.9 in the 4th bay, FA5.1 to FA5.4 in the 5th bay, and FA6.1 in the 6th bay of the existing *RH2* switchboard will be disconnected from the existing busbars of the *RH2* switchboard and connected to the new busbars from the 7th bay of the switchboard.

Option B:

In the event of a complete reconnection of the laser technology rooms on the 1st floor SO02 from the S network to the fail-safe U network of the UPS2 source, it will be necessary to modify both the main *RH2* switchboard located in the LV substation and the main UPS2 *RUPS2* switchboard located in the UPS source room.

In the UPS room, it would be necessary to install another new 3rd pole of this switchboard with a width of 600 mm (500 mm) behind the corner of the 2nd pole of the *RUPS2* switchboard, with a depth of 600 mm, identical in design to the existing one, with a four-pole circuit breaker with a rated current of 800 A (transfer of part of the UPS2 power supply) and its connection by cables at the top to the busbars of the second pole of the existing *RUPS2* switchboard. This third pole would be connected by cable to the newly modified *RH2* switchboard in the LV substation.

With regard to the installation of outlet circuit breakers for the switched-over switchboards in the 5th and 6th poles of the *RH2* switchboard (6 poles in total), it will be necessary to make fundamental modifications to the existing main LV *RH2* switchboard. Next to
the 6th field of the switchboard, a 7th field with a width of 800 mm, a depth of 600 mm, and a maximum height of 1900 mm will be added, identical in design to the existing switchboard, while the side cover of the 6th field of the switchboard will be removed and
The 7th pole will be connected to the existing switchboard to form a single unit. The 7th field of the switchboard will be equipped with a four-pole circuit breaker with a rated current of 800A connected to the existing busbars of the switchboard and a four-pole switch with a rated current of 800A connected by a cable from the rear of the UPS2 *RUPS2* uninterruptible power supply switchboard. The circuit breaker and switch will be mechanically interlocked to prevent simultaneous switching with manual control for manual manipulation of the connection of the specified loads to the S network or the UPS2 RUPS2 uninterruptible power supply. Both elements will be equipped with status signaling to the existing MaR system of the building in accordance with the building standard. The outputs of both elements will be connected together to new busbars with a rated current of 800A installed in the lower part of the new 7th field of the switchboard and extended to the existing 4th - 6th fields of the switchboard above the main existing busbars of the *RH2* switchboard.

The existing circuit breakers FA5.2 to FA5.4 in the 5th bay and FA6.1 in the 6th bay of the existing *RH2* switchboard will be disconnected from the existing busbars of the *RH2* switchboard and connected to the new busbars from the 7th bay of the switchboard.

Option C:

As can be seen from the energy balance table for option B, highlighted in color, the existing supply of the uninterruptible power supply U to the existing Lb4 laser technology switchboard on the 1st floor of *the RI.00.040* laser hall is not sufficient in terms of power in the event of a request to switch all existing powered loads from the S network to the uninterruptible power supply U.

In the event of reconnecting the aforementioned Lb4 switchboard from the S network to the UPS2 uninterruptible power supply network, it will only be necessary to modify the main UPS2 *RUPS2* switchboard located in the UPS room and the outlet from the *RH2* switchboard for the aforementioned switchboard.

In the existing UPS2 power supply switchboard, an outlet circuit breaker with a rated current of 250A would be added to the free space in the first field of the *RUPS2* switchboard (the existing outlet circuit breaker in the main *RH2* switchboard for the specified outlet is 400A), to which it would be possible to connect a maximum power input of only 150kW, which would be sufficiently dimensioned for the current power consumption with a sufficient reserve of approx. 100 kW, without taking into account the possibility of connecting a 25 kW load to the existing uninterruptible power supply U in the switchboard room. Together with the circuit breaker, a measurement of the electrical energy consumed by the outlet will be added, connected to the existing system for measuring the electrical energy consumption of some outlets from the main LV switchboards.

The existing cable outlet from the *RH2* main switchboard of the S network to the *RI.00.040* switchboard would be disconnected in the *RH2* switchboard, the cable would be connected with a cable of the same cross-section and extended to the UPS power supply room.

5.2.4. Cable routes

The cable routes will be made of copper all-plastic conductors with separate working and protective neutral conductors in a fire-retardant CXKH-R, B2 s1 d0 design. Existing cable routes in the 1st basement floor of the LAB building between the LV switchboard and the UPS power supply room will be used to the maximum extent possible.

5.3. Connection of the planned PV system to the existing building electrical installation

To reduce the energy consumption of the building, photovoltaic panels for electricity generation will be installed on the roof of SO02. The system will use photovoltaic converters to supply the electricity generated from solar radiation to the building's electricity distribution system.

The system will be designed by a specialized company with an expected output of 320kWp, approx. 290kW. With this expected output of the photovoltaic system, the nominal current on the 400V low-voltage side will be approx. 600A.

5.3.1. Electricity supply

With regard to the current consumption from individual transformers, see section 4.1, it seems most appropriate to connect the photovoltaic power plant to the power distribution of transformer T3 via the main switchboard *RH3*. The constant consumption of the SO02 building's ventilation machine rooms from this switchboard (according to actual data from measurements of average electricity consumption installed on the outlets for ventilation machine rooms from the main switchboard *RH3* for the last year from 05/2020 to 05/2021) is 294 kW, so the electricity generated would only cover part of the electricity consumption of the entire building and would not supply surplus electricity to the distribution system operator's grid.

In the fourth field of the *RH3* switchboard, a three-phase circuit breaker with a rated current of 630A will be added to the free position, to which a cable for connecting the PV system to the power distribution system will be connected via a cable route at the top of the switchboard. Along with the circuit breaker, a meter for measuring the electrical energy supplied by the PV system will be added, connected to the existing system for measuring the electrical energy consumption of some outlets from the main LV switchboards.

5.3.2. Cable routes

The cable routes will be made of copper all-plastic conductors with separate working and protective neutral conductors in a fire-retardant CXKH-R, B2 s1 d0 design. Existing cable routes in the LV substation will be used to the maximum extent possible. The main riser cable route from the LV switchboard on the 1st basement floor to the 3rd floor of the LH laser hall will follow the existing riser route in the LB laboratory building at the level of the HVAC machine room. Alternatively, it would be possible to use the main riser route for the 3rd and 4th floors of LH located in the middle of the wall between LB and LH. This main riser leads from the 1st basement floor to the 3rd floor of LB and passes through the 3rd floor into the LH building, where it rises under the ceiling of the 4th floor and passes into the northern air conditioning machine room. A cable tray for new cables would have to be added in the passage under the ceiling of the 4th floor.

Both risers are inaccessible and walled up in some areas, or located in suspended ceilings, so the installation of new cables would require construction work on the building (demolition, bricklaying, plaster repairs, painting, etc.).

The installation of new cable lines as described would be carried out together with the cables according to paragraph 5.3. Where routes pass between fire compartments, the penetrations will be sealed with fire seals or sealing compound, e.g., INTUMEX.

5.3.3. Other

In the event of a request from the designer of the photovoltaic power plant project documentation to control the power plant's output with regard to the supply of electricity to the distribution system operator's grid in the event of a distribution network failure, a cable connection will be made using a control cable between the USM metering cabinet located in the LV substation and the main FTV switchboard located on the roof of building SO02 at FTV, routed together with the FTV power cable.

6. ESTIMATED INVESTMENT COSTS

6.1. Reinforcement of the electrical supply for floor S SO 02 (3rd floor LH)

Total CZK 1,840,000 excluding VAT
(excluding construction modifications for the riser line from 1st floor SO02 LB to 2nd floor SO02 LH)

6.2. Power supply stabilization for building SO 02 (primarily L and E floors – 2nd basement and 1st floor LH)

Option A:
Total CZK 1,550,000 excluding VAT

Option B:
Total CZK 665,000 excluding VAT

Option C:
Total CZK 860,000 excluding VAT

6.3. Connection of the planned PV system to the existing building electrical installation

Total CZK 678,000 excluding VAT
(excluding construction modifications for the riser line from 1st basement SO02 LB to 4th floor SO02 LH)

7. CONCLUSION

This study was prepared based on the documents provided by the customer on June 7, 2021, and complies with the requirements of ČSN and safety regulations.

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