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Studying the fundamentals of sustainable architecture in FEFU: regional experience and prospects

Abstract: Due to the character of the architectural profession, education in sustainable architecture in Architectural and urban planning department is now focused on studying the principles and ways of forming “an ecologically-dependent architectural space” by looking into the peculiarities of its development in the context of regional conditions. The 3-year experimental course “Fundamentals of Ecological Architecture” at FEFU for the last 25 years is mostly focuses on the following objectives: - Principles and ways of forming a climate-oriented architectural design; - Dependence of the building architecture on integrated active and passive systems by utilizing renewable energy sources; - Peculiarity of indoor and outdoor vegetation systems of buildings; - Prospectively, for masters level, nature ecosystem integration into the urban environment. The experience of implementing the standards of green architecture in educational design showed that, while maintaining the current criteria for evaluating student projects, environmental education in an architectural institution cannot go beyond the scope of the experiment.
Key words: environmental education, sustainable architecture, green design, bioclimatic architecture

Students proposal for the FEFU campus future sustainable development.
“Research Center of Energy Efficient Technologies” at the Far Eastern Federal University. Author - Natalia Bakaeva, Bachelor’s Degree Program.

Introduction

These days, the architecture in Russia is viewed as a professional activity not related to ecology. Even nowadays, the topic of environment conservation and sustainable development and eco-architecture coexists in absolute isolation from each other. Ecological architecture in Russia has not been recognized as a very efficient way of forming a sustainable and environmentally friendly human habitat.

This fact could be the main reason behind the situation where nowadays, ecological education in architectural school includes only a few introductory courses and labs. As a result, the issue of increasing energy efficiency in buildings is viewed only from an engineering technology point of view which could be resolved by efficient insulation, interior climate control and energy conservation methods in residential and commercial buildings.

Thus, constant growth of knowledge about methods of creating sustainable anthropogenic environment demands not only a new model for education but also an elaborate approach on how eco subjects are to be taught within the existing curriculum. At the same time, due to the character of the architectural profession, education in sustainable architecture has to be focused on studying the principles and ways of forming "an ecologically-dependent architectural space" by looking into the peculiarities of its development in the context of regional conditions [1].

The 3-year experimental course "Fundamentals of Ecological Architecture" at FEFU is mostly focuses on the following objectives:

- Principles and ways of forming a climate-oriented architectural design. Analysis of annual wind and insolation changes, levels of precipitation and humidity; researching the possibility of adapting to them using architectural means, e.g. by changing the geometry of open space and volumes, applying the bioclimatic landscape design, rationalizing the exterior envelope design, and interior space-planning solutions (1);
- Dependence of the building architecture on integrated active and passive systems by utilizing renewable energy sources. Primarily, solar power for domestic hot water and heating supply, photovoltaic systems and wind power generators; performance of these systems is often directly correlated to the chosen architectural solutions (2);
- Peculiarity of indoor and outdoor vegetation systems of buildings, including: city farms, photobioreactor-based systems (algaetecture); dependence of the building form on the selected method of vegetation. Architecture of buildings is viewed as a method of forming a comfortable microclimate for outdoor and indoor vegetation systems (3);
- Prospectively, transfer to consideration of building architecture and urban open space requirements for the partial or more extensive revitalization of the original ecosystem and its integration into the urban environment during academic process (4);

Academic program does not aspire to cover the entire issue of developing a sustainable architecture; it primarily considers design peculiarities of resource-efficient systems of indoor and outdoor urban spaces that are the primary objective for a "green architect". Obviously, the challenges of resource conservation while choosing building materials, method of building construction, engineering systems for creating a comfortable environment, and social factors, have to be addressed during academic process in cooperation with related university departments.

Experience and results

Initially, the basics to this course (1) were introduced in 1992-99 and explained the specifics of the monsoon climate in the south of Russian Far East at middle latitudes. Specific characteristics include a high contrast of the horizon sides, microclimate features of the indoor and outdoor spaces depending on the direction and intensity of climatic factors [2, 4] (Fig.1, Fig.2).

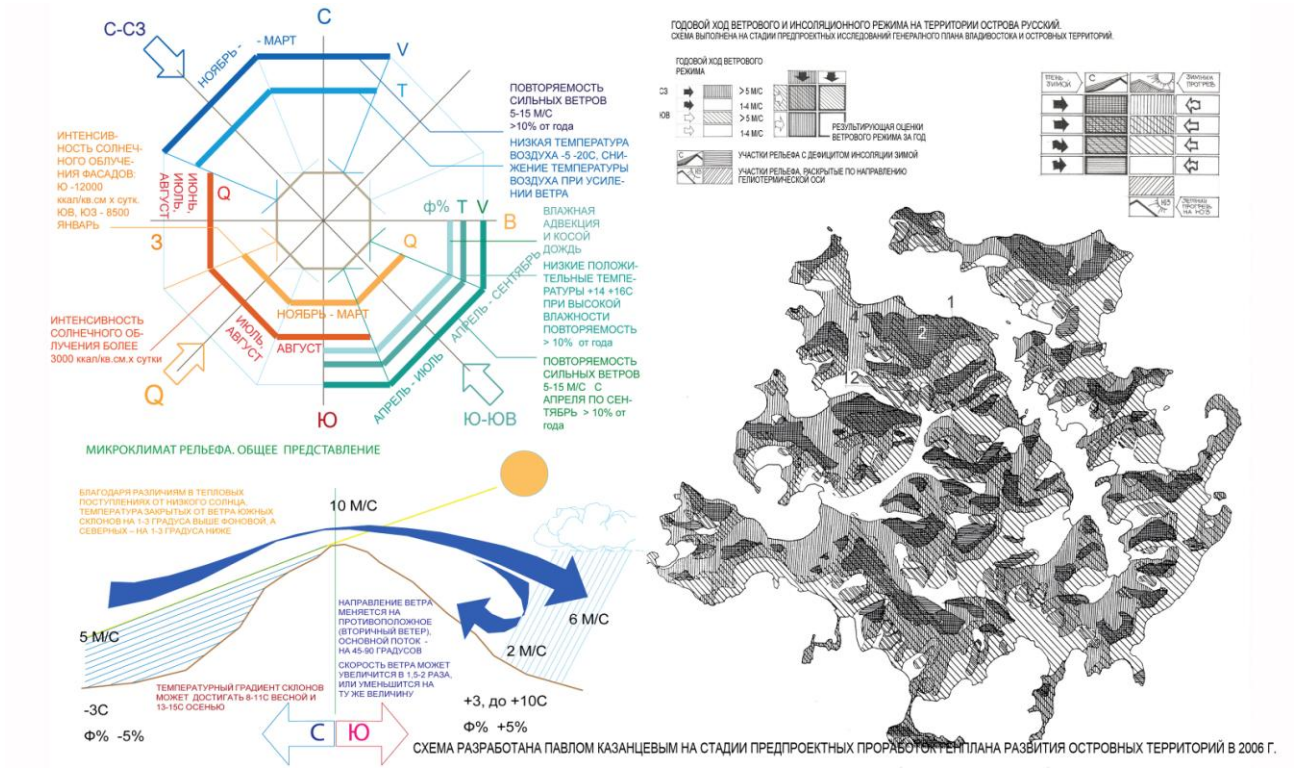

Fig. 1. The map of the wind-solar zoning of the Russky Island and the monsoon climatic rose shows the main features of local climate: a combination of high contrast sides of the horizon and ridged hill landform. Southern part of the Russian Far East has unique climate conditions. It is difficult to find another such city on the territory of Russia, like Vladivostok, within the borders of which - on the opposite banks of Golden Horn Bay – where the recommended duration of the heating season differs by 40 days [2, 4].

Fig. 2. Downtown and panoramic view of Vladivostok taken from the Russky Island during the calm. Urban Planning solutions are not related to the context of regional conditions and directly affect the environment. Industrial zones in valleys surrounded by hills; central heat supply in the Southern Primorye which is literally sun bathing during winter; increased car use in the city with a ridged hill terrain with minimal public transportation - the reasons for the formation of a stable smog bubble over the city districts, especially in windless seasons. Modern Vladivostok is a maritime city and the complete calm is a rare phenomenon.

This approach is not completely new: if we look at traditional architectural solutions among planet's climate zones, we'll immediately notice their dependence on local conditions. Traditional architecture was formed during thousands of years by trial and error and has always been context-conscious and environment-dependent – complying with the requirements of the climate, terrain and natural resources at inhabited area by humans for centuries. Thus, the architecture has always been resource-efficient and sustainable.

In the Southern part of the Eastern Russia, the academic process also has to consider the fact that the traditional architecture of the tribes that used to inhabit Primorye, Priamurye and neighboring regions of Manchuria was almost erased by the Mongolian invasion about 600 years ago. In 19th century Russian pioneering explorers and settlers didn't consider the distinctive features of the local climate and relied on the construction principles and techniques typical to the European part of the Russian Empire. Therefore, the lecture part of the course focuses on the theoretical fundamentals of modeling a comfortable architectural environment influenced by the vector and related climate factors. As a result, in absence of direct architectural equivalents the experience of architectural designs in the neighboring monsoon regions has been used (Japan, Korea and China). In 1992, the students of the Far Eastern State Polytechnic University created first experimental designs for resource-efficient buildings, which included townhouses and single-family dwellings with passive and active solar heating, "solar" country club house. In the early 1990s, when few people in Russia knew about ecological architecture, the students' interest to the energy-efficient design was triggered by the unique natural climate conditions of the Southern part of the Eastern Russia and the lack of attention to the design during that time.

In 1999, after 7 years of experimenting, the Department of Design had developed a set of labs for the course "Fundamentals of Ecological Architecture" for the third to sixth year students of the Environmental Design Program. Student projects have covered the major principles and techniques of resource-efficient architecture, starting from the easiest, basic concepts of principles taught during the lectures of the Architectural Physics course (3rd year, 6th semester). These labs were integrated into Architectural Design Studio in the 6th-7th semesters in compliance with University Calendar for the Environmental Design Program. This experimental practice resulted in publishing the course materials - "The Fundamentals of Ecological Architecture" in 2008 and "Fundamentals of Ecological Architecture. Design of energy-efficient buildings." in 2012.

Fig.3. Graduation Project by Yuliya Korkina. One of the best projects performed during course experiments with eco-architecture of the Environmental Design Program. Instructors: Pavel Kazantsev, Evgenia Lapshina.

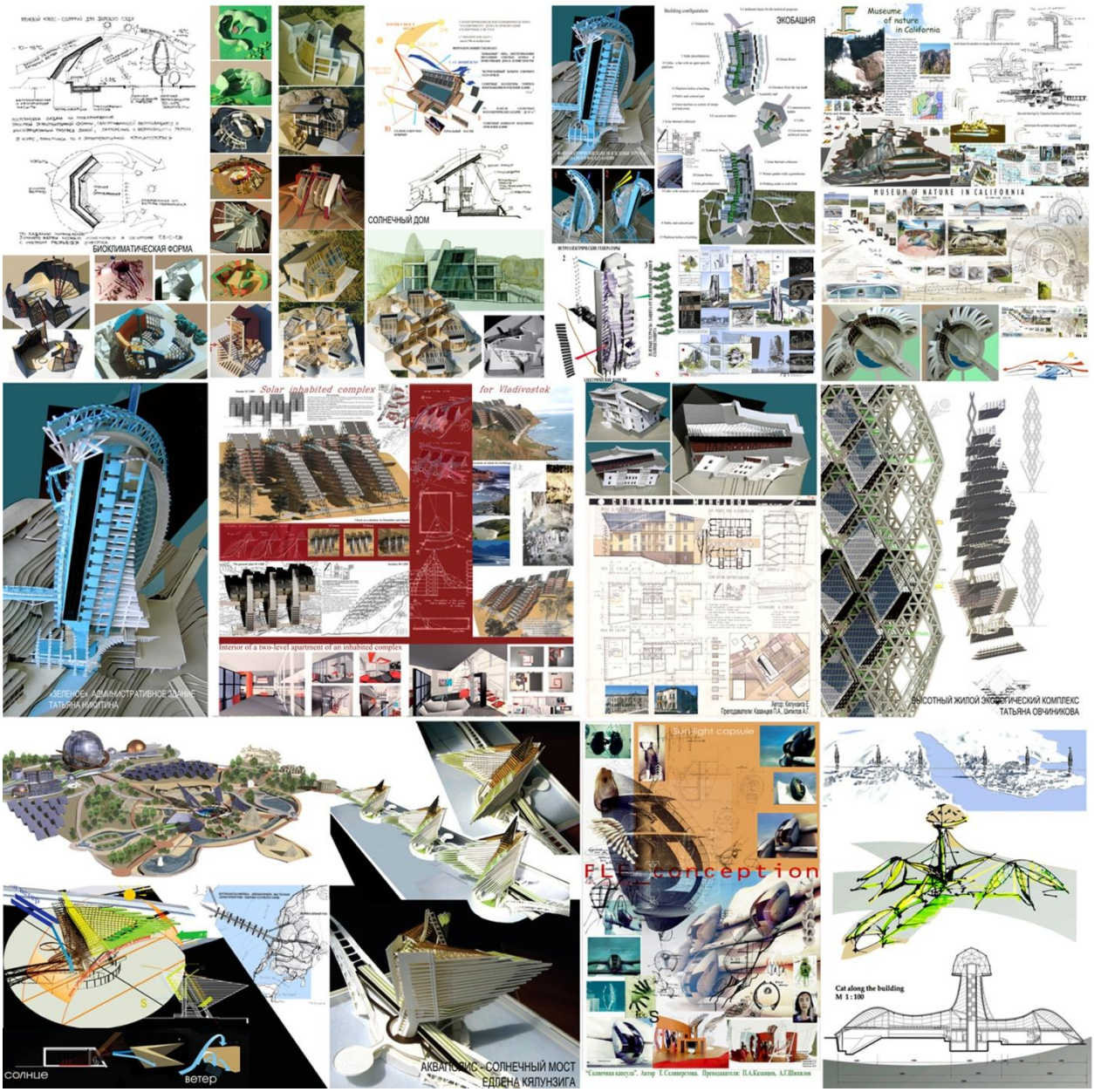

Fig.4. Review of student projects up to 2011. The main projects of the Environmental Design Program at the Department of Design in FESTU - design of a "simple" bioclimatic form (1); low-rise house or habitable attic with passive and active solar heating (2); the study of Ken Young's "eco-skyscraper" concept (3); oriented and bionic architecture in diploma projects. Instructors - Pavel Kazantsev, Andrey Shipilov; students - Ekaterina Gorelova, Dmitry Savushkin, Tatyana Nikitina, Elena Kelunziga, Tatyana Ovchinikova, Alexander Kuznetsov, Tatyana Seliverstova, Ekaterina Lezhnenko.

After the establishment of the Far Eastern Federal University, the course of ecological architecture was continued at the Department of Architecture and Urban Planning within the FEFU School of Engineering. In 2015, the studio, which specializes in ecological design, was officially renamed to “Resource-Efficient Architecture Studio”. Projects performed by the student members of the studio are based on the actual challenges and suggest alternative environmentally friendly design solutions for the Vladivostok and Southern Primorye.

Design of “simple” bioclimatic form – a solar pergola-solarium for a daycare remains as a basis for the introductory part of a series of course labs. A minimal functional load of the form allows students to concentrate on studying the possibilities of regulating the summer and winter insolation and wind patterns. Currently, the students have switched from physical modeling to 3D-modeling and further studying of its characteristics via simulators of insolation and wind using the

student version of FlowDesign software (3rd year, fall semester). Developing project requirements in 1990s, the author used the principles suggested by A.V. Yakovlev (refer to Urban Construction in the Far North [5]). The assignment "Sun Clock Square" is a simplified version aimed a consolidation of the knowledge of the annual solar coordinates (Fig.5).

Fig. 5. Simple bioclimatic shape and Sun Clock Square, physical models by the 3-rd year students.

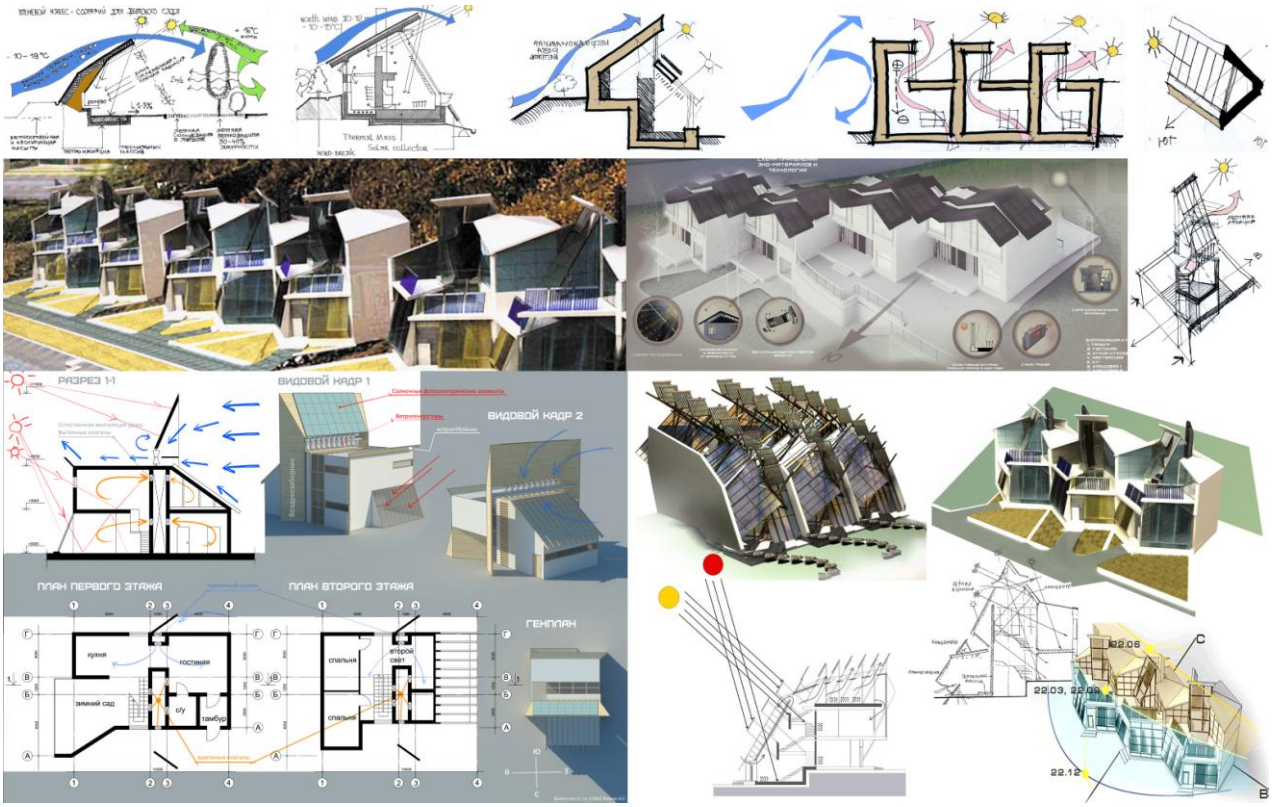

Fig.6. Passive Solar Single-family House and Townhouses. Sketches and projects by Oksana Gritsay, Anastasia Smelovskaya, Alexander Ryumin, Tatiana Ovchinikova and Daria Lubaeva, analytic sketches by Pavel Kazantsev

Project “Country Townhouse” exposes students to the potential of passive solar heating for the Primorye region and integration of active solar systems into design (Architectural Design Studio, 3rd year, fall semester). As much as possible, project design development is complemented with field trips. First trip is to a competed single-family dwelling with passive solar heating, built between 2014-2016, which was the first eco-house in Russia of straw bale construction with Solar-SB passive heating. Second trip is to the FEB RAS Institute of Marine Technology where students observe an operating active solar hot-water supply system. However, Prototype Build Program for academic and research purposes was not fully realized due to the reorganization of the FEFU, which resulted the first built experimental Eco-Module Solar-5M being located in a remote area unreachable to the students (Fig. 6, 7, 8).

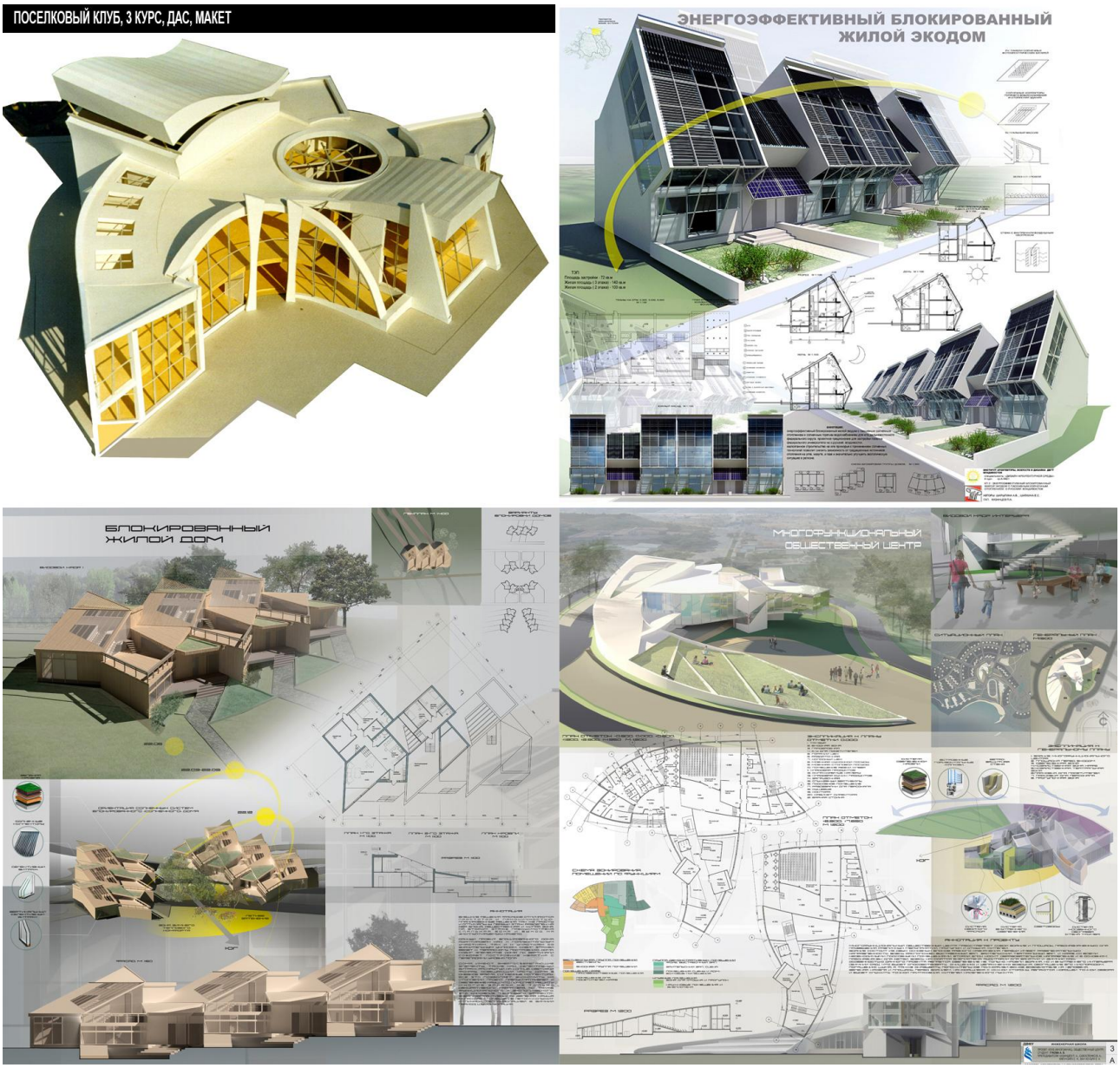

Fig. 7. Third year students’ projects submitted after the introductory lecture of the course "Fundamentals of Ecological Architecture". Country Club (by Irina Fisun, 2003) and Townhouse (by Anastasia Sharygina, 2010) with passive solar heating (major "Environmental Design"). Country Community Center and Townhouse with passive solar heating (by Anna Gukova, 2015) (major in "Architecture").

Fig.8. Students' field trip to the straw bale eco-house Solar-SB (left); assembly of the Eco-Module Solar-5M at the FENTU technopark (right). Educational process is forced to use examples from a private sector. The possibility of field trips relies on personal relationship of professor Pavel A. Kazantsev with his clients.

The Project "School" faces contradictory requirements of the comfort daylight level in the classrooms and building's passive solar heating; insolation preservation and wind comfort at open spaces, mentioned above deepen students' knowledge of passive the solar technologies. Ilya Svistunov's project design features natural daylight and passive heating at classrooms, by using skylights and double-glazed facades, providing the visual connection of the rooms with the outdoors (water view to the bay from the north, in the direction of the winter monsoon), building form protects a school yard from the north (Fig. 9, 10, 11).

Fig. 9. Project "School" by Ilya Svistunov, 4th year, Bachelor's Program. Cross Section of the windbreak block in the "north-south" direction see left corner of the pictures.

Fig. 10. “FEFU Boarding School on Russky Island” by Anastasia Levshchanova, Bachelor’s Program. Closed from the winter wind, the southern side allowed the author to concentrate on the aspects of solar architecture designing the school. Terraced educational and residential blocks, open to the south are an optimal form for passive solar heating and for location of active solar systems. Double glazed facade regulates an excessive insolation in classrooms.

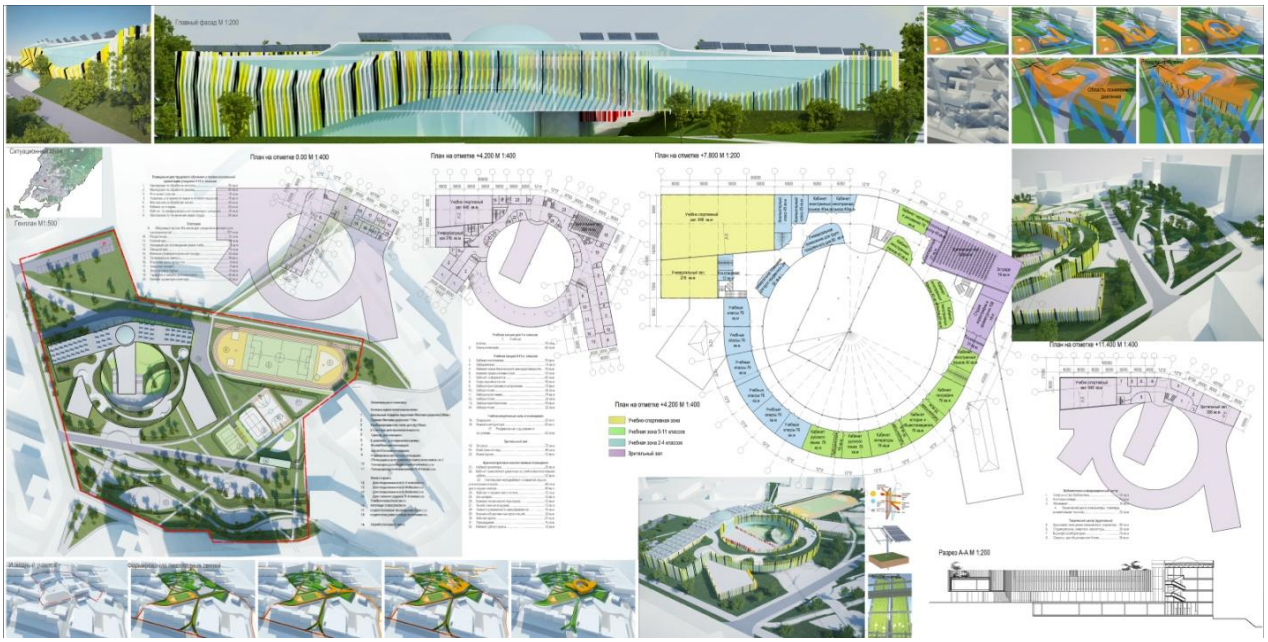

Fig.11. Project "School" by Anton Santcevich. Linear public block - windbreaker from northern winds; the radial shape of a school yard is an optimal for insolation during winter; horizontal sunshades combined with photovoltaic panels - protect interior space against excessive insolation from the south.

Studying the interaction between architecture and monsoon winds, regulation of insolation climate in the existing urban environment and in the newly developing sites has remained an important topic in course projects [3]. In contrast to the recent past, students currently use the methods of computer simulation of winds and insolation patterns. The Project “Hotel”, a multi-storey building in the existing urban environment, focuses on the form modeling with consideration of summer and winter monsoons, preserving existing comfortable environment for pedestrians.

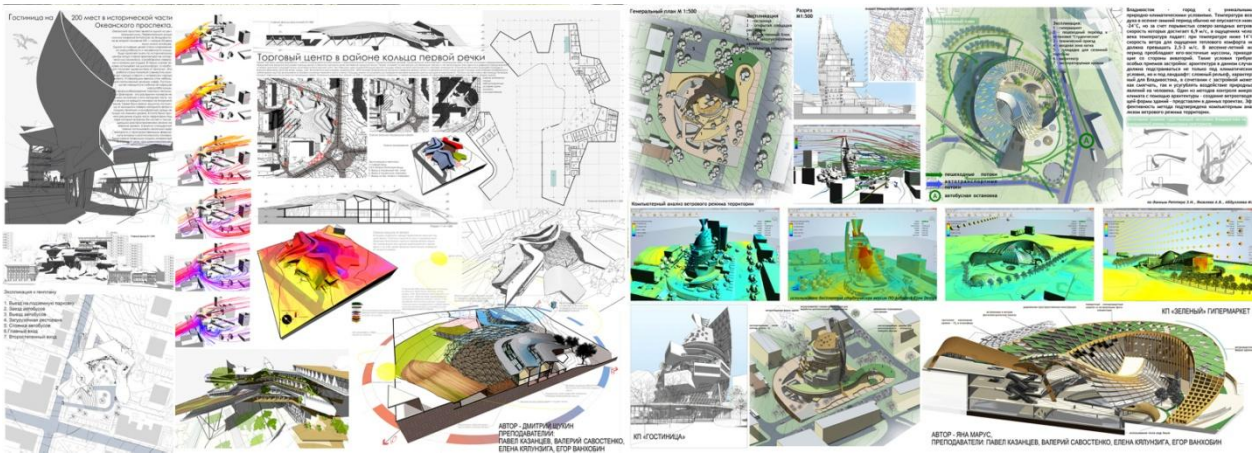

Fig. 12. Evaluation of wind and insolation using computer modeling. Fragments of Projects “Hotel” and “Retail Mall” by Dmitry Shchukin and Yana Marus. Autodesk FlowDesign Student Version.

Fig. 13. The new buildings in Vladivostok gives a unique material for the study of the microclimate. The study of the microclimate of the new hotel on Cape Burnyi allowed Margarita Shvedova to develop an alternative form of the building. Closed from the wind and open to the sun courtyard creates a comfortable environment for citizens. While the realized tower forms flows of the strong wind on it’s territory.

In 2005, Project “Ecological Tower” was introduced into the 5th year of Environmental Design Program – a high-rise energy-efficient building located in city’s downtown. The original idea by Ken Yang [6] was chosen as a methodological foundation for this project. A similarity of climate conditions (monsoon of Eastern Asia) combined with a dramatic latitude difference (between the tropical area and Primorye) allowed students to find common features in the architecture of the Primorye region without replicating Yang’s ideas, thus encouraging them to develop their own creative side. In addition to the information on passive and active solar systems, the students studied the methods of vegetation in the urban environment, use of wind energy and integration of rainwater collecting systems into their design solutions (three months of fogs and wind-driven rains in the region).

Presentation of the course “Fundamentals of Ecological Architecture” at the World Sustainable Building Conferences SB05 (student's session) established relationship with Tokyo University of Science (Tokyo, Dr. Kazuhiro Kojima), Instituto Politecnico Nacional Mexico (Dr. Martin Gomestagle), which allowed to organize international master classes “Eco-Dwelling" and "Eco-Tower" in regions with contrast climate conditions” in 2006 and 2009 (Fig.14, 15).

Nowadays, due to the transfer to Bachelor's Program and shortening of the academic process from 6 to 5 years, this project had to be included into Studios of the course "Sustainable Architecture Development". Only 4 labs are devoted to developing a project design for ecological high-rise building, which resulted in schematization and reduction of level of detail. Study of vegetation systems as part of public buildings was partially resumed in the Project "Retail Mall" (Bachelor's Program). Integration of the "urban farm" is one of the project requirements Experiments of young instructors, former Master Program students – graduates of the "Green Studio" – allow students to study design characteristics of "urban farms" in the region. The experiment is led by Yegor Vanhobin, and participants: Yana Marus, Daria Burdina, Ekaterina Frolova and Daria Pirogova. (Fig.16).

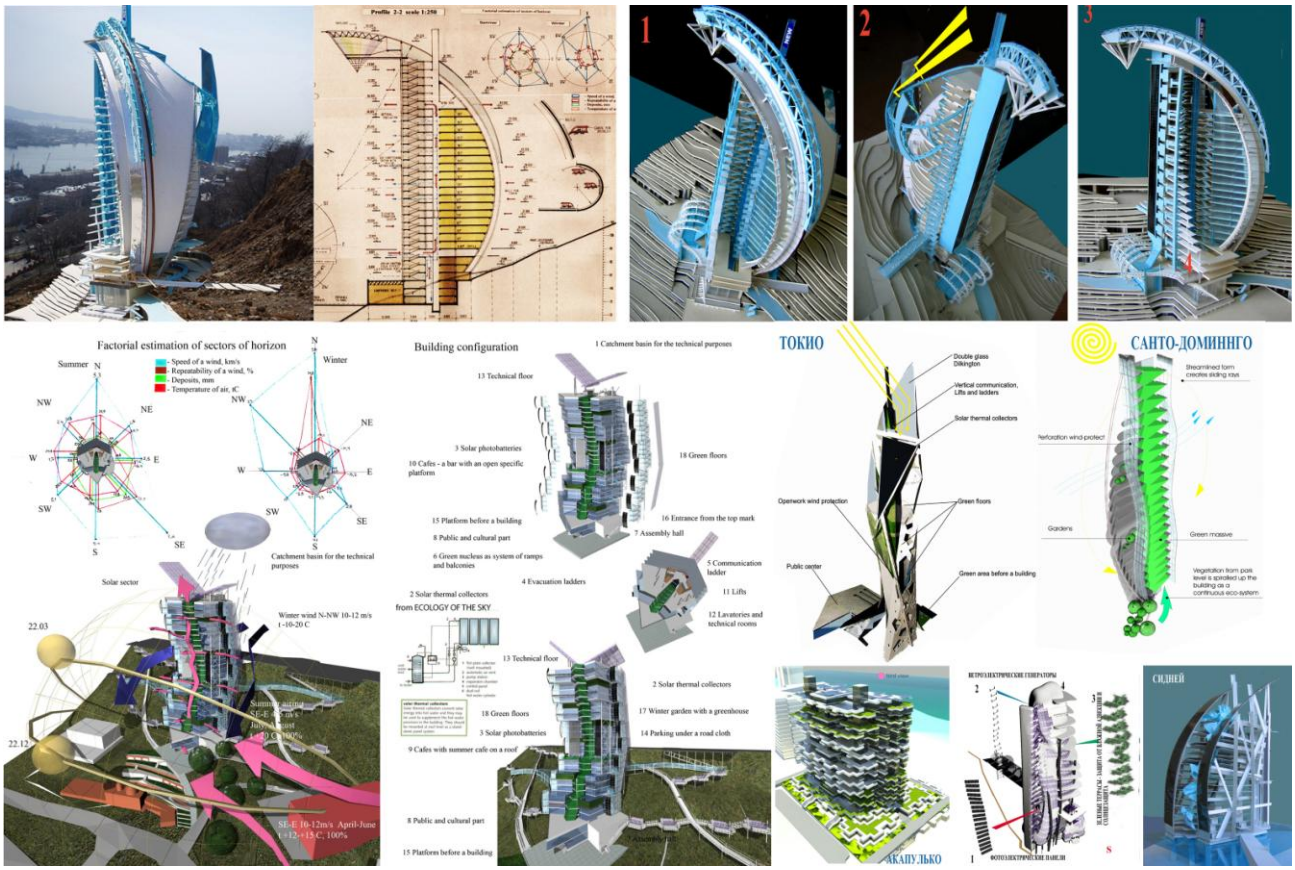

Fig.14. Project "Eco-Tower" by Elena Kelunziga, Tatyana Nikitina, Ekaterina Movchan, Dmitry Savushkin, Vasily Zeleznakov: sketches, drawings and physical models, 2005. Ken Young's original concept of "Green Skyscraper" in students' interpretation (Environmental Design Program).

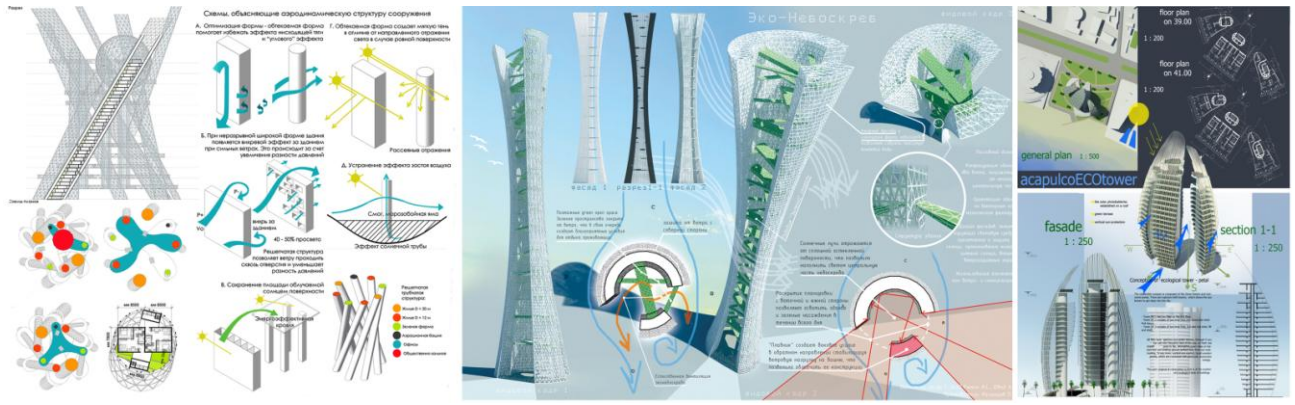

Fig. 15. Study sketches by students Mariam Vartanyan, Alexandra Ryumin, Irina Karpenko

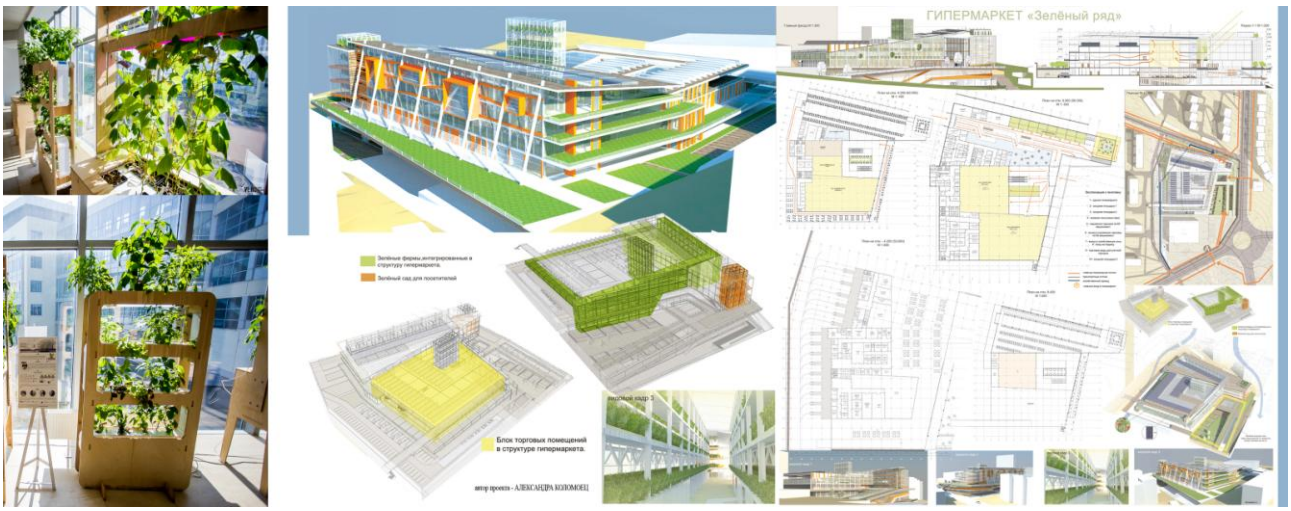

Fig. 16. Project “Retail Mall with the Urban Farm” by Alexandra Kolomoets. Left part the experimental setup "urban farm" in the FEFU Engineering School hall.

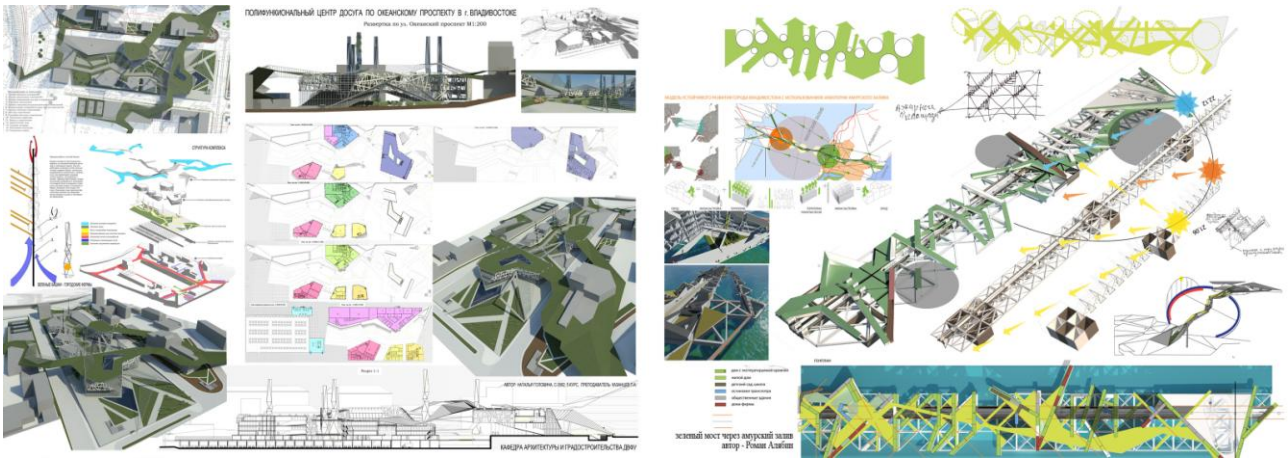

Fig. 17. Project “Vertical Gardens” - "green lungs" of a public building in a dense urban environment by Natalia Golovina (left). Project “Ecological Bridge across the Amur Bay from Hasan provincial park to the future forest-park belt in the Pervaya River valley” by Roman Alyabin (right).

Fig. 18. Project “Dwelling with the Urban Farm in Madrid” by Anastasija Smelovska and Galina Chernysheva (Bachelor’s Program)

At the same time a greater proportion of residential projects in Architecture Program, in comparison with Environment Design Program (4th year spring semester), allow a deeper study of the peculiarities of forming a sustainable living environment in the regional context. The student's experiments allowed a new look at the structure of residential development in Vladivostok. Traditional Vladivostok city blocks acquire a new vision - horseshoes, opened to the sun and positioned opposite to the wind, which creates comfortable living conditions during winter and the first half of summer. Preservation of the unique city landform, the use of renewable energy sources and building materials, development of urban farms, provision of social sustainability - is also included in the range of assignments solved by students in course projects (Fig.19).

Fig. 19. Project "Residential Development" by Daria Vorobyeva (Burdina), Yana Marus, Tatyana Korznikova and Ekaterina Osokina, Alexander Kalmykov. (Bachelor's Program, Specialist Program)

Overview of the graduation projects: bachelor's and master's degree programs

The topic of a "green" graduation project is an individual choice and primarily determined by the creative skills and interests of the graduating student. Only general requirements are defined: the project has to be connected with the development prospective for the southern Primorye and should rely on the engineering ideas of the FEB RAS in sustainable use of marine resources and resources available in the south of the Eastern Russia. Examples of buildable and futuristic Graduate Projects are shown on figures 20-34.

Fig. 20. Graduation Project "Residential Area Renovation in abandoned fishing village on the island territories of Vladivostok". Partial presentation. Author - Daria Burdina.

Fig. 21. "Residential Area Renovation in village "Rybokombinat". Pedestrian street view.

Fig. 22. Graduation Project Master's Program "The Horizontal Residential Structures". Preserving the city's unique natural landform by soaring over the hills of Vladivostok. Partial presentation. Author - Evgeny Silin.

Fig. 23. Graduation Project, Bachelor's Program. "Research Center of Energy Efficient Technologies for FEFU". Motto: open the "building face" to the sun, oppose "back" to the wind, and from the north - push the building into the landform. FEFU campus buildings (phase I) on Russky Island facing north fully glazed facades, and the streets of the western part of the campus create solid wind corridors, since they are stretched along the prevailing direction of the monsoon. Partial presentation. Author - Natalia Bakaeva.

Fig. 24. Graduation Project Bachelor's Program. "Archeological and Ethnographic Museum of Indigenous People". Deepen into the earth "inert" architecture is another promising way for areas with a ridged hill landform to save energy and the territory. Partial presentation. Author - Evgenia Sharapova.

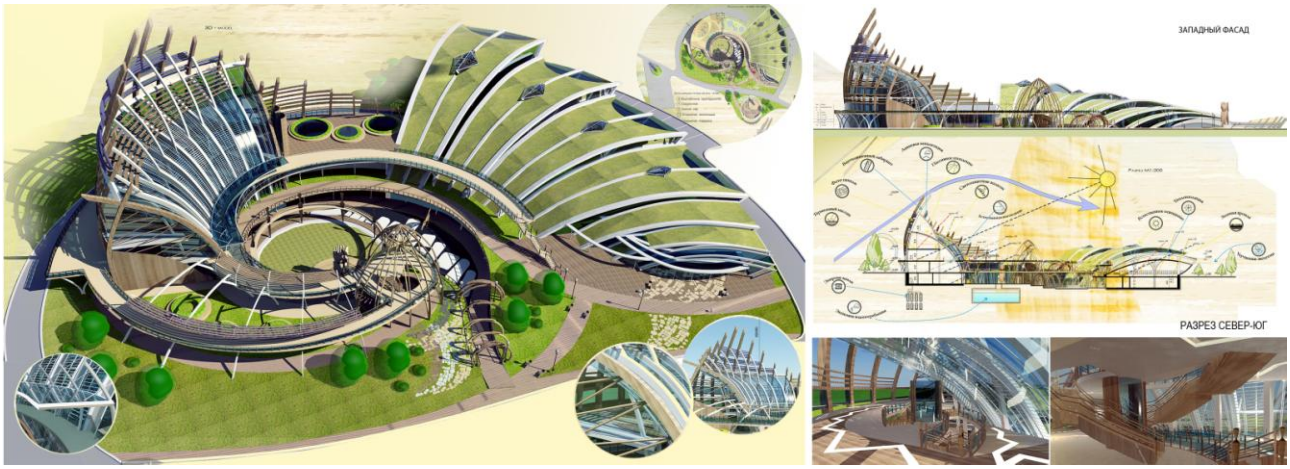

Fig. 25. Graduation Project Environmental Design Program. "Landscape and Ethnographic Center on Popov Island". Facing to the sun the main block and greening roofs of research spaces. Partial presentation. Author – Anastasija Sharygina.

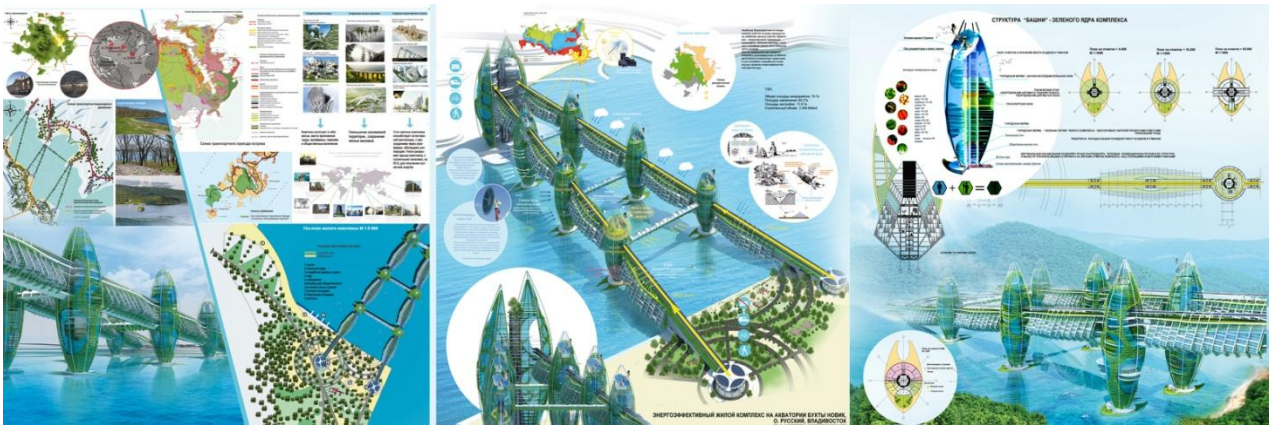

Fig. 26. Graduation Project "Ecological Residential Development - Bridge". A bridge over Novik Bay includes solar power plant and solar heating systems, urban farms - "green lungs" of the buildings and rainfall water collection etc. Partial presentation. Author - Oksana Gubanova.

Fig. 27. Graduation Project Specialist's Program "Residential Development". Analysis of the sea level rise is a core urban planning aspect in the formation Vladivostok's coastline protective structures. Partial presentation. Author -Alexandra Kolomoets.

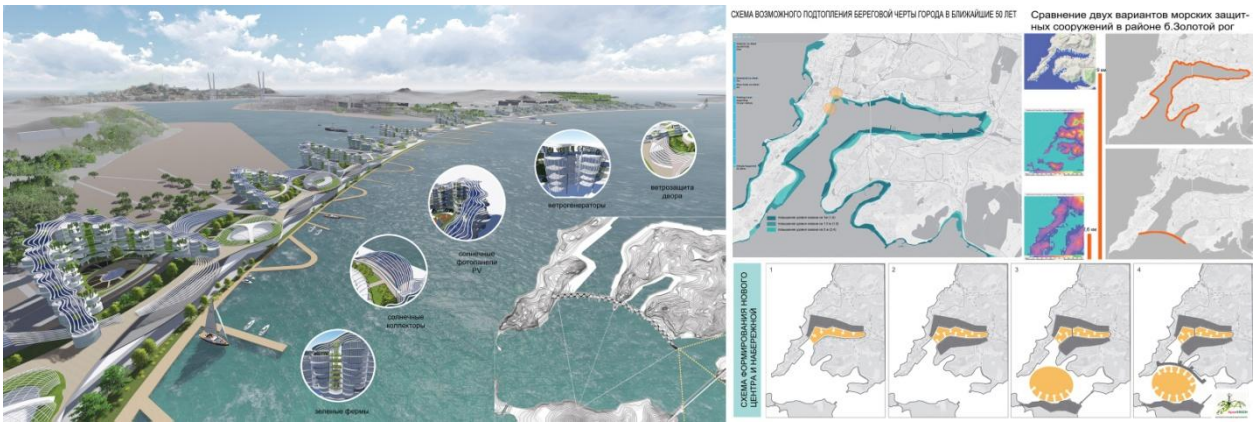

Fig. 28. Flooded territories at nearest future and their protection.

Fig. 29. Graduation Project "Agro Tourism Park". Building form shaped around courtyard as a response to the wind and insolation climate of the area. Exhibition pavilions utilize passive technologies forming a comfortable environment. Pavilions' central "towers" - "green hearts" of the buildings - ensure the inertness of the internal environment irrespective of the weather condition changes during the day. They participate in the "solar heating" of the halls in the winter, rainwater collection and ventilation in the summer. The inspiration came from traditional architecture of the Middle East: the "wind" towers and domes. Partial presentation. Author – Anastasia Kravchenko.

Fig. 30. Graduation Project, Bachelor's Program. "Center for Forecasting and Prevention of Natural Disasters". The heart of this architectural design is not only the author's original motto – "the planet in man's hands", but also a detailed simulation of the building's form behavior under the constant storm winds at cape Krasny. Partial presentation. Author - Svetlana Kazak.

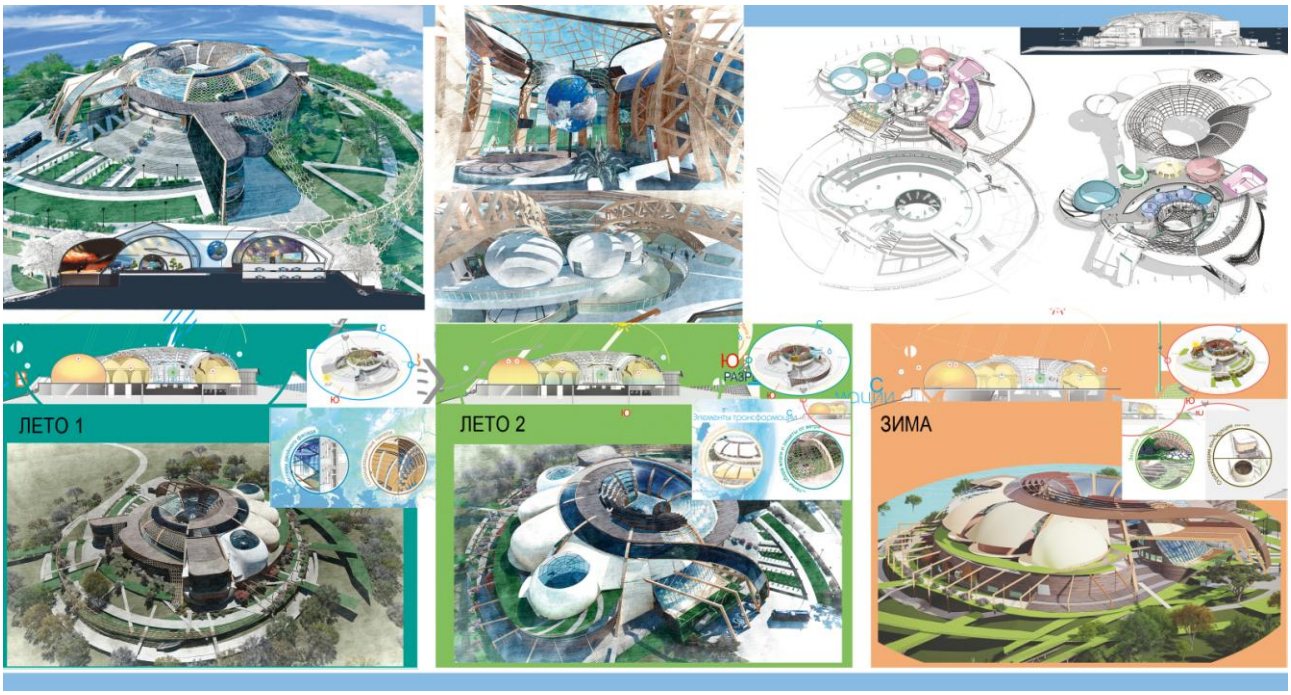

Fig. 31. Graduation Project "Transforming Research Center - "Weather House". Motto: "in winter we are covered and gain the sun heat, in the spring we collect rainwater and protect ourselves from fogs, in the summer we reduce overheating using sun protection and ventilation". Partial presentation. Author - Yuliya Rihert.

Monsoon climate changes form certain weather conditions, therefore climatologists frequently say that Primorye does not have its own weather. For six months from November to March - Primorye "lives" in continental Siberia, until mid-July when it sees all of the delights of the "northern coast summer", and from the middle of July until the beginning of September it falls into the tropical heat [3, 4]. To summarize, the architecture of the region should not only be "Siberian" in winter and adapt to the "cold summer" in April-June, but also meet the "Philippine standards" in July-August.

Fig. 32. Graduation Project “Center for Environmental Education on Popov Island”. Design takes into account three seasons of maritime weather. Glass cubes - winter gardens with a top light adapt to changing weather conditions, which helps maintain constant comfort in the educational zone. Partial presentation. Author - Margarita Shvedova.

Fig. 33. Graduation Project, Bachelor’s Program. Water-sensitive urban development for Diomid Bay’s catchment basin. Partial presentation. Author - Ekaterina Osokina.

Fig. 34. Graduation Project, Master’s Program. “Polyfunctional Bionic Structures. Prototype of Future Vertical Cities (regional aspect)”. Partial presentation. Author - Maxim Malygin.

Conclusions

Inclusion in the design tasks of the requirements for the formation of a resource-saving environment significantly increases and complicates the range of tasks to be solved in the training project. And, while maintaining the previous evaluation criteria, green projects often lose to classical course and diploma work. It must also be taken into account that these requirements for the formation of a sustainable environment are not included in the compulsory curriculum of

architectural design. Therefore, even from the students who came to the "Resource-Saving Architecture Workshop", not everyone can withstand the set standards. Usually it is not more than half the flow, 5-7 people. The experience of implementing the standards of green architecture in educational design showed that, while maintaining the current criteria for evaluating student projects, environmental education in an architectural institution cannot go beyond the scope of the experiment.

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Изучение основ экологической архитектуры в ДВФУ: региональный опыт и перспективы

Аннотация: Учитывая особенности архитектурной профессии, образование в области устойчивой архитектуры должно быть сосредоточено на изучении принципов и приемов формирования «экологически-зависимого» архитектурного пространства, и изучения особенностей его формирования в контексте региональных условий. Трехлетний экспериментальный курс «Основы экологической архитектуры» в ДВФУ в основном фокусируется на следующих учебных задачах: - Принципы и приемы формирования климатически-ориентированного архитектурного пространства; - Зависимость архитектуры здания от интегрированных активных и пассивных систем использования возобновляемых источников энергии; - Особенности формирования внутренних и наружных систем озеленения зданий; - В перспективе, в целом рассматривать архитектурные особенности интеграции природных экосистем в городскую среду. Опыт внедрения стандартов «зеленой архитектуры» в учебный процесс показал, что при сохранении текущих критериев оценки экологическое образование в архитектурном вузе не выйдет за рамки эксперимента.

Ключевые слова: экологическое образование, устойчивая архитектура, экодизайн, биоклиматическая архитектура