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Fulfillment Testing Standards in Design of Pre-School Facilities as a Basis for Architectural and Urban Transformation in the Context of Energy Efficiency

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ABSTRACT

This paper analyses examples of existing kindergartens' buildings in Serbia in terms of meeting the requirements of spatial capacity and compliance with the minimum standards of required area. Surveyed buildings are dating from various periods. Over time, their environments have undergone numerous changes and interventions, so it is important to establish whether basic requirements are been violated. The second parameter is the degree of land availability, and the existence or nonexistence of free space for possible intervention aimed at changing urban context. Finally, the third aspect is the possibility of using the closest environment to amend the urban environment parameters that would affect the local climate change, reducing outside air temperature in summer or increasing in winter, changing direction or stopping unwanted effects of dominant winds. Namely, by the influence on the input parameters, the need for thermal insulation and the method of ventilation could be changed. The norms are dealing predominantly with the external building envelope and with the insulation, which is necessary, but the last in a series of interventions and by far the most expensive, as a solution. Due to frequent climatic anomalies, global trends are going in the direction of prevention, while interventions have been aimed at the urban environment and the use of space resources. Possible changes in city planning, transformation and revitalization of the area would also have a significant impact on the physical environment and the energy efficiency of buildings.

KEYWORDS: urban regeneration, urban interventions, energy efficiency, kindergartens, revitalisation

1 THEORETICAL BASIS AND NORMS

A starting point for the analysis and discussion in the paper are the norms for planning, construction and equipping of pre-school buildings, published in the Official Journal of the City of Belgrade No. 11/72. Also, the actual experience and trends in the design of the pre-school buildings, kindergartens, here are used as referential parameters.

According to regulations, the optimal required size for the building site of the pre-school building is 30m^2 per user (a child). There are variations, if the form of irregularly shaped parcels is not suitable for establishing playgrounds and sports fields, then the overall area of the site is to be increased to 40m^2 per a child. If the location is leaning on the other open, green and park areas, then it is possible to reduce the area to 20m^2 per child. In a case of an inherited structure of a whole city or building or adapting other purpose building into preschool building, the area then can also be reduced, but not below the 10m^2 per child. Among the analysed cases, only two are such: "Svitac" in Nis and "9. Jugovića" in Leskovac (No. 28 and 31 in Tables). Here, the problem is more pronounced in the kindergarten in Nis ("Svitac"), while the kindergarten in Leskovac ("9.Jugovića") has a larger area and is located on a plot in the per-urban area, nearby the park area, that gives greater advantage. Other surveyed kindergartens may be classified into two categories; in small number of cases the plots are in the parks or other similar areas, but far more buildings are located within the built urban environment. Therefore, for this paper purpose this parameter is, as a referential, adopted with following values: minimum requested area of the building site is $20m^2$ per child but more favourable is $30m^2$ per child with the exception in the two mentioned cases.

According to the same norms, minimal built area of the kindergarten is $4\text{-}10m^2$ per child, provided they do not exceed 1/3 of the total area of the site. The legislature provides a variety of cases, from $6m^2$ per user, if it is adapted building and $6.6m^2$ per user, if the object is within the urban environment and the maximum number of children per group is reached. The more favourable value is $8\text{-}10m^2$, suggested for the new developments. Since the most common case is the kindergarten built in urban area, the adopted referential value for the gross area is $6.6m^2$ per child. Therefore, the following two relationships and parameters are taken for this paper analysis: the average area of the building per a single user and floor area ratio (FAR), the ratio of gross floor area to the gross plot area.

The next parameter is not defined by any standards, but has a limiting character in the possible future transformation of buildings. It is the form and the type of rooftops. A slant roof as well as a flat roof do have own specificities in terms of subsequent interventions and transformational potential. Here must be used different design approaches.

The parameters that clearly affect the size of the building area and the plot area are the size of the group (the maximal number of the children in a group), the kindergarten capacity (maximal number of the children in whole facility) and the distance from the place of residence in accordance with the size of the corresponding urban settlements. For the building capacity, 240-360 users per building are considered an optimal, and for the maximal distance from the residence, 15 minutes walking distance or 500m. Considering neighbouring environment, it is envisaged that the higher adjacent buildings should be located at least two of its height from the kindergarten (relevant only for the rooms occupied by children). Elements related to the physical distance from the adjacent buildings, their relations and correspondence are also important because they define the kindergartens' surrounding space. As such it can be greatly limiting factor for transformational potential of the open area on the plot.

2 RELEVANCE OF THE SPECIMENS

The survey included 35 kindergartens, 17 of them are in the city of Nis, and other are in towns in Southeast and Western Serbia. The years of construction vary greatly. There are fifty years of range while the oldest one was built in 1960 the last one was built in 2012. This means that in this survey a significant period of construction time was taken into account, and in architectural and in any other terms it is sufficient for the relevant analysis of the parameters given above. This time range influenced the adjustment of the original parameters in use, which is the reflection of the social, demographic, economic, environmental, urban and other transformations, which the society and the country have gone through. Here we compared the buildings of kindergartens of different age through the several parameters and that gave interesting results.

There is an imbalance in the number of buildings constructed in relation to the year of construction. The largest construction expansion was in the period up to the 80's when the largest number of analysed kindergartens were built, which coincides with the period of industrial development and population expansion in the cities. The period of 90's and the end of the twentieth century were marked by social turmoil, early transition, the growing crisis, wars, lower standard, so many companies had been shut down, which also had caused a decrease of investments in these public facilities. In this period there are only a few newly constructed kindergartens. Only after 2000 it began again to be paid attention to the issue of social and child care, resulting in new constructions of the kindergartens, but not as a result of the increase in the birth rate, because in many parts of the country, the population even decreased or remained constant. The need for the parents to do a fulltime and even an overtime job affected the revaluation of these facilities.

The analysed samples included a great number of kindergartens observed with the defined territory. This especially applies to the territory of Nis, which is demographically the third largest city in the country, but also smaller towns and cities, such as Leskovac, Bor, Kuršumlija, etc. In the area of Nis this survey covered over 80% of kindergartens (17of 21) that are currently in use. In terms of size, this survey covered the kindergartens with the capacity from 70 to 450 users, but most common are kindergartens with 200-250 users. The database we made included single-storey buildings, but as well buildings with two or even three floor levels. Also the buildings converted into the kindergartens are included in survey. They are not so common because of the specific needs of buildings designed for children. Almost complete database of kindergartens in each surveyed city brought "a new light" into the overall survey. Providing an overview of the development and monitoring of child care facilities in parallel with the development of the city, and its urban population. Also, this database included the information about the disposition of facilities within the city, from the central urban, per-urban to the peripheral areas. From the all above it can be affirmatively treated the relevance of the specimens used for the analysis.

3 SPATIAL ANALYSIS

According the analysis above and adopted average values of parameters, the comparative results we have gotten are not encouraging. 40% of the total number of analysed buildings does not met requirements. Taking into account the date (year) of construction (Table 1, column 3), the older buildings are equally represented among those ones that fulfil and those that do not fulfil the requested conditions, while the structures built during the 90's and at the beginning of this century have less area than needed. However from 2004 onwards all facilities meet the norms. Undoubtedly, this significantly compromised with the quality of children's care in the facilities. Interestingly, the above applies equally to all buildings, regardless the number of children. The older buildings are usually overloaded, there is much larger number of users than the capacity and the norms allow, causing lowered quality of the provided services for the children. On the other hand, the newer buildings, usually the small ones, are in the central city zones and that suggests some other trends, but it does not abolish lowered standard.

The next analysed parameter is the distances between the residence and the kindergarten. Defined normative value is 15 minutes walking distance or 500 meters. On one hand, kindergarten building seeks for free space, obtaining an adequate environment and climate, sufficient natural light, greenery and free sports areas for play, sport and recreation of children needed for a proper physical development of children. This is in direct conflict with the distance and associated demographic zone. Earlier mentioned optimal occupancy per building, 240-360 children to which the facilities once had been adapted, today have raised to 400, and even 450 users, which is evidently the overload. Contemporary research and practice in the world are going in the direction of the formation of smaller units to reduce the number of children per building, and a small number of groups is favoured, which requires smaller building units, but also the shorter distance from place of residence. This further frees up space for free and green areas. This is also good for social and psychological development of children, as it is more appropriate for the development of the child to be in small groups in order to express its individuality and yet be properly socialized.

The ratio between the existing area size of the plot (Table 1, column 7) and the calculated size of area (Table , column 8) according to the number of children (Table 1, column 6) and the given norms is also an indicative fact. There is no essential difference between the new and old buildings and the number of children in the facilities. More than 50% of the facilities do not meet this criterion, if the adopted average value is $20m^2$ for the urban areas in city close to parks and green space, and $10m^2$ for kindergarten "Svitac" in Nis, which is a converted building. If we adopt a basic norm of $30m^2$ to be optimal, the number of buildings that do not have sufficient area of the plot would increase to alarming 80%. It is evident that by this parameter conditionality of these facilities is questionable, regardless of other parameters, which may provide adequate quality, but they are not the subject of this paper. The similar situation is for the floor area ratio (FAR) (Table 1, column 13), which in over 60% of the analysed examples exceeds the maximum of 0.33, in more than 30% of examples it exceeds 0.50, and even in 15% exceeds the value of 1.

The next important parameter for the analysis is BpP/PR (Table 1, column 12). Here the situation is much more favourable. In 30% of examples, the value is above 0.33, while in 2/3 of examples this value is in the optimal range. This information is very important because it gives us information about the open, free space around the building.

Table 1 Analysed kindergartens in Southeast and Western Serbia, data about number of floors, the plot size, gross floor area, BpP/PR, FAR, normative (expected) area size according to users number and defined norms, heating mode (BR- boiler room, EE – el. Energy, DH - distance heating, O – oil, C - coal) and form of roof (F – flat roof, S – slant, Sa- slant with attic)

No.	**Name of institution**	**Year of construction**	**City/ Town**	**Number of total floors**	**Total number of children**	**Actual plot size (m^2)**	***Normative plot size (m^2)***	**Built-up area (m^2)**	**Actual Gross floor area - GFA (m^2)**	***Normative GFA (m^2)***	**BpP/PR**	**FAR**	**Type of roof**	**Heating mode**
1	2	3	4	5	6	7	*8*	9	10	*11*	12	13	14	15
1.	Naše dete	1960	Leskovac	2	180	**1745**	*3600*	472	**944**	*1188*	0.27	0.54	F	BR, EE
2.	Đulići	1969	Zaječar	2	250	**4535**	*5000*	1080	1984	*1650*	0.24	0.44	Sa	DH
3.	Lane	1973	Pirot	1	370	**5514**	*7400*	1541	**1541**	*2442*	0.28	0.28	F	DH
4.	Šećerko	1974	Ćuprija	1	118	**1760**	*2360*	867	1052	*779*	**0.49**	0.60	S	N/A
5.	Kolibri	1975	Niš	2	400	**3119**	*3040*	815	1629	*1003*	0.26	0.52	S	BR, O
6.	Bajka	1975	Niš	2	152	**4481**	*8000*	830	**1792**	*2640*	0.19	0.46	Sa	BR, O
7.	Bambi	1976	Bor	2	215	5860	*4300*	1750	2482	*1419*	0.3	0.42	S	DH
8.	Lane	1976	Leskovac	2	260	5900	*5200*	995	**1268**	*1716*	0.17	0.22	S	BR, EE
9.	Maslačak	1976	Niš	3	240	**2580**	*4800*	759	2166	*1584*	0.29	0.84	F	N/A
10.	Bucko	1976	Soko Banja	3	220	7000	*6400*	1290	**2095**	*2112*	0.18	0.30	S/F	N/A
11.	Zeka	1977	Kragujevac	2	129	2900	*2580*	526	1259	*851*	0.18	0.43	F	DH
12.	Naša radost	1978	Kruševac	1	220	6600	*4400*	1360	**1360**	*1452*	0.21	0.21	S / F	DH
13.	Bambi	1978	Niš	2	196	4882	*3920*	908	1758	*1294*	0.19	0.36	F	DH
14.	Crvenkapa	1978	Niš	2	260	**2650**	*5200*	888	**1438**	*1716*	**0.34**	0.54	S	DH
15.	Sunce	1979	Kuršumlija	1	450	11200	*9000*	2645	**2645**	*2970*	0.24	0.24	S	BR, O
16.	Boško Buha	1979	Vranje	2	136	6926	*2720*	909	1563	*898*	0.13	0.23	Sa	BR, O
17.	Pepeljuga	1980	Niš	2	200	**2607**	*4000*	918	1359	*1320*	**0.35**	0.52	Sa	DH
18.	Neven	1981	Niš	2	235	**2056**	*4700*	908	2360	*1551*	**0.44**	**1.15**	F	DH
19.	Kolibri	1982	Vlasotince	1	159	5765	*3180*	1219	1219	*1050*	0.21	0.21	S/F	BR, C
20.	Cvrčak	1983	Niš	2	171	**1539**	*3420*	911	1682	*1129*	**0.59**	**1.09**	Sa	BR, O
21.	Plavi Čuperak	1983	Niš	2	400	**1365**	*8000*	700	**1460**	*2640*	**0.51**	**1.07**	Sa	DH
22.	Snežana	1987	Knjaževac	2	135	**1464**	*2700*	495	990	*891*	**0.34**	0.68	Sa	BR, O
23.	Kolibri	1988	Leskovac	2	270	**3380**	*5400*	959	**1013**	*1782*	0.28	0.3	Sa	BR, EE
24.	Neven	1990	Prokuplje	2	178	**593**	*3660*	293	**868**	*1175*	**0.49**	**1.46**	S	N/A
25.	Zvončići	1992	Niš	2	215	**4260**	*4300*	568	1820	*1419*	0.13	0.43	Sa	DH
26.	Vilin Grad	2000	Niš	2	323	**5870**	*6460*	946	**1476**	*2132*	0.16	0.25	Sa	DH
27.	Slavuj	2001	Niš	2	220	**2175**	*4400*	772	**1041**	*1452*	**0.35**	0.48	S	BR, O
28.	Svitac	2002	Niš	2	100	**813**	*1000*	443	**443.4**	*660*	**0.55**	0.55	S	BR, O
29.	Bubamara	2003	Niš	1	314	**3200**	*6280*	937	**936.8**	*2072*	0.29	0.29	Sa	BR, O
30.	Petar Pan	2005	Niš	2	160	4700	*3200*	820	1512	*1056*	0.17	0.32	Sa	DH
31.	D. Jugovića	2007	Leskovac	3	190	11146	*3800*	630	**1260**	*1294*	0.06	0.11	S	DH
32.	Pčelica	2008	Požarevac	3	70	1670	*1400*	497	1987	*462*	0.30	**1.19**	S	N/A
33.	Biser	2009	Niška Banja	2	110	9250	*2200*	659	1144	*726*	0.07	0.12	S	BR, O
34.	Cvetić	2011	Niš	3	204	6573	*4080*	904	1947	*1346*	0.14	0.3	Sa	BR, O
35.	Prokuplje	2012	Prokuplje	2	120	**2348**	*2400*	979	1126	*792*	**0.42**	0.48	Sa	BR, EE

* buildings are ordered by year of construction
in **bold are given the numbers that do not meet the adopted norms, in *italic* are given adopted normative values

4 THE FORM AND SPATIAL TRANSFORMATIONAL POTENTIAL

A goal of this analysis was not the developmental capacity of the buildings in terms of increasing the number of the users. Here we strived for finding the capacity for the improvements in the area of better functional organisation and energy efficiency of the buildings. We can conclude that only a several buildings have this transformational potential. To this group belong the buildings that have dispersed form that can be reformed into a compact form with or without the atrium. Naturally, it is always possible to make some major transformations, but it is not the goal of this analysis. Also, there is a possibility for massive transformations inside of some buildings, by conversion or adding new parts. Some of the buildings are built with modular raster, so it is possible to make some developmental transformations, but not transformations in order to improve the energy efficiency. Mainly, majority of the buildings is already completed building structures so that without expensive and radical interventions they cannot be improved.

Figure 1: Kindergarten “Boško Buha” (1979) Vranje, significant transformational potential of the building

5 SURROUNDING OF THE BUILDINGS AND TRANSFORMATIONAL POTENTIAL

The plots have usually a regular form, but in majority they are with inappropriate size for any kind of intervention. This is common situation, regardless the city of origin, number of users, and position in the city (central or per-urban area). Site plans are basically with the same organisational scheme, the building is close to the street, on the sides, adjacent buildings are also relatively close, while backyard are is usually used for space for playground and sport courts. The plots of bigger size, even with the irregular form, have far more better possibilities for transformation. There are also small sites that could not be transformed at all. Sometimes, the orientation also can be a problem, if the play yard has Northern orientation.

To sum up, a great problem is limited developmental potential of the plots. The plots of the analysed buildings (60% of all) do not have any developmental potential; in 20% of the analysed cases the sites have only limited potential. That leave us only 20% of the cases that have enough area for intervention that could give us certain positive results.

There is spectrum of different situations. The plots within the city centre usually caused the situation where the kindergarten is built with insufficient distance to the adjacent building. But most of the plots are properly located and organized, where neighbour buildings are far enough, but usually without any additional space for the intervention (50%). Surrounding areas is usually occupied with parking, tall residential buildings that exclude adding some new greenery in the block. Still, there are a number of the cases where the plot is large enough to consider some kind of intervention (50%). That case are usually in per-urban areas or at the edges of the central urban zones, and it doesn’t matter if there is tall or low raise neighbouring buildings.

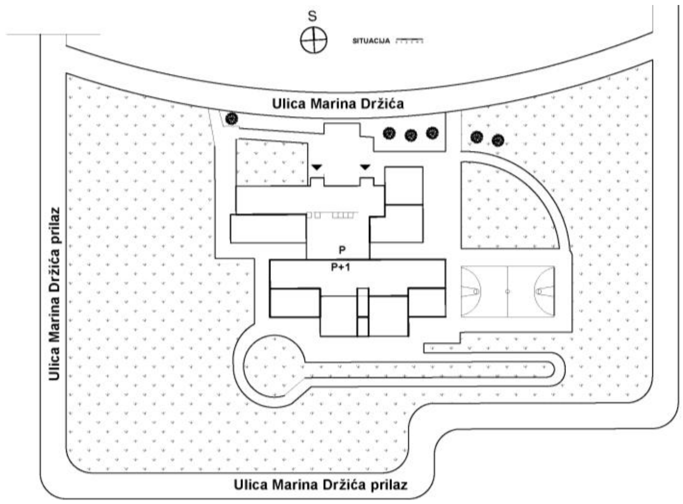

Figure 2: Kindergarten "Pepeljuga" (1980) Niš, significant transformational potential of the site;

Table 2 Analysed kindergartens, data about form of the buildings, size of the site, surrounding areas and possibilities that have for the transformation (X- have potential, x-limited potential, DN- distance from the neighbour is satisfying, LMT-limited by shorter distance from the neighbour)

No.		**The Form and Spatial Transformational Potential**		**The Site and it's Transformational Potential**		**The Neighbourhood and it's Transformational Potential**	
1.	Naše dete, Leskovac	compact		LMT		at the limit of normative value	
2.	Đulići, Zaječar	compact		limited by form	x	DN	x
3.	Lane, Pirot	dispersed	x				
4.	Šećerko, Ćuprija	compact			X		X
5.	Bajka, Niš	compact		limited by form		DN, low-rise buildings	
6.	Kolibri, Niš	compact		limited by form	x	DN	x
7.	Bambi, Bor	dispersed		LMT		DN, low-rise buildings	x
8.	Lane, Leskovac	dispersed	X	regular form		DN	X
9.	Maslačak, Niš	compact		limited by form		at the limit of normative value	
10.	Bucko, Soko banja	compact		limited by form		DN	
11.	Zeka, Kragujevac	compact		small		DN	x
12.	Naša radost, Kruševac	dispersed		problem with orientation		DN	X
13.	Bambi, Niš	dispersed	x	LMT	x	DN	x
14.	Crvenkapa, Niš	compact		LMT		DN	
15.	Sunce, Kuršumlija	dispersed		irregular form	X	DN	X
16.	Boško Buha,Vranje	dispersed	X	irregular form	X	DN	X
17.	Pepeljuga, Niš	dispersed		free	X	DN, low-rise buildings	X
18.	Neven, Niš	compact		small		at the limit of normative value	
19.	Kolibri, Vlasotince	compact		limited by form	x	DN, low-rise buildings	X
20.	Cvrčak, Niš	dispersed	X	free		DN, high-rise buildings	
21.	Plavi Čuperak, Niš	compact		small		bellow the limit of normative value	
22.	Snežana,Knjaževac	compact		irregular form, small		DN, low-rise buildings	
23.	Kolibri, Leskovac	dispersed	X	regular form	x	DN	
24.	Neven, Prokuplje	compact		small		at the limit of normative value	
25.	Zvončići, Niš	compact		regular form	X	DN, high-rise buildings	X
26.	Vilin Grad, Niš	compact		regular form	x	DN, low-rise buildings	X
27.	Slavuj, Niš	compact		regular form		at the limit of normative value	
28.	Svitac, Niš	compact		small		DN, low-rise buildings	
29.	Bubamara, Niš	dispersed		irregular form, small, LMT		DN, low-rise buildings	x
30.	Petar Pan, Niš	compact		free	X	DN, high-rise buildings	X
31.	9 Jugovića, Leskovac	compact		free		DN, high-rise buildings	X
32.	Pčelica, Požarevac	compact		LMT		at the limit of normative value	
33.	Biser, Niška Banja	compact		free		DN, low-rise buildings	
34.	Cvetić, Niš	compact			x	surrounded by streets	
35.	Prokuplje	compact		small		DN, low-rise buildings	

Figure 3: Kindergarten “Petar Pan” (2005) Niš, significant transformational potential of the area (neighbourhood)

6 CONCLUDING REMARKS

Savings of energy that is used for heating during winter time and also for cooling in summer can be achieved in two ways. First one is to reduce the amount of used energy by improving of the building insulation, organisation of the building, spatial disposition; meaning by architectural measures on and in the building and by urban interventions within the surrounding area. Second way is by achieving a higher level of energetic independence by installing different modes of energy sources, mostly renewable energy sources. In this case the main focus is on solar panels and cells, while windmills would not be suitable for this type of building.

The analysis of the spatial capacities of the plots and the buildings, in almost 50% of the all cases, has shown that the transformational potential is very limited. Level of BpP/PR is also giving us the confirmation that those buildings are without any spatial capacity that can be used for the improvements of energy efficiency. Free space around the buildings is generally insufficient to receive larger greenery, with combined trees or even some water areas (a pond or a fountain). Water could have a great role in making better microclimate that would have positive affects to the amount of energy in use.

Slant roof, with or without the attic, are in majority of cases. Every sixth building has a flat roof. Slant roofs are better for rain and snow, but green roofs are then impossible to install. Usage of green roofs would significantly improve the energy efficiency, but also it would rise the percentage of the greenery on the site. Enlargement of the green areas improves the quality of the ambient, but also visual quality of the building and the whole site. Direct benefit of the green roofs is the reduction of the thermal energy exchange between the indoor and outdoor air. There are the examples that have shown that during summer period this reduction could be between 7-90%, and during winter 10-30%. Those researches have given us the example where low rise greenery (ordinary grass) was used in a layer of 20-40cm (including sub-layer) and by outdoor temperature of 30°C, the indoor temperature was reduced by 3-4°C. It is not difficult to assume the amount of energy that can be saved by using this approach in reconstruction of buildings. Unfortunately, this solution cannot be used for slant roofs. Any kind of intervention on slant roof could not be rational.

The second aspect, the possibilities of making a less energy depending building, is in these surveyed buildings very minimal. On one hand, there is lack of large enough open spaces where would be possible to install solar panels. Also, these installations should be out of reach of children. Also, slant roofs are not quite suitable for solar panels, or they must be fixed so less efficient. A good aspect is possibility of usage of the attics for the equipment and installations (more than 50% of buildings do have the attic), while at those ones without the attic, could be far more expensive to install such structures. Around 15% of buildings have flat roof, which is in the case of installing a solar panels better, because it is possible to install systems that can by adjusted according to the movement of the sun during the day for maximal efficiency.

In almost 50% of the cases there is a boiler room in the buildings, so the buildings is heated independently, while in other cases the buildings are connected to the distance heating system. So it is necessary to calculate additional spending on maintaining the boiler room and installations, and also on fuel (oil, coal or electrical energy). Without any doubts this mode of heating is far more expensive. Distance heating is far better solution, but it depends on the central plant, quality of the conducting systems etc. In that way an independent heating system could be favoured, but it would be necessary to find a cheaper fuels.

It is evident that all surveyed buildings are overloaded; number of children exceeds the capacities of the building and the site, in majority of all cases. This implicate two conclusions, a need to reconsider the network of kindergartens within a city (there is a need to build more buildings) and also reconsider (reconstruct) the existing buildings in order to be suitable for children in accordance with theirs psychological, developmental and physical needs and contemporary trends as well. In this context, it is possible and recommended to use contemporary trends in green building and bioclimatic design that would significantly improve energy efficiency, reduce the energy usage and exceed the energy independence, while the quality will not be in question.

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