



# **Green Energy-Efficient Schools for Albania**

**Prepared for the  
Albanian Ministry of  
Education and Sport**

**June 2015**



# Green Energy-Efficient Schools for Albania

A Report for



REPUBLIKA E SHQIPËRISE  
MINISTRIA E ARSIMIT  
DHE SPORTIT

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## Executive Summary

The Albanian government's commitment to sustainability, the country's favorable climate for renewable energy initiatives, and an overall enthusiasm for education among its citizens make Albania an ideal environment for a thriving "green schools" movement. With investments from both the international community and the Albanian government, the country is well positioned to transform education, generate employment opportunities, and boost GDP by engaging in a greening process in its schools. A series of changes to improve energy efficiency, air quality, indoor/outdoor facilities, and other design elements will:

1. Improve health, safety, and comfort conditions;
2. Provide uninterrupted electricity in schools;
3. Generate 220,000 new jobs; and
4. Increase GDP by US\$880 million.

These achievements will also pave the way for Albania to launch a solar industry nationwide and become a leader in the green schools movement regionally.

In a recent study commissioned by the Albanian Ministry of Education and Sports and sponsored by the Open Society Foundation of Albania, Arizona State University's Walton Sustainability Solutions Initiatives evaluated the opportunities, challenges, impacts, and costs for making Albania's more than 3,300 school buildings safer, healthier, and more energy-efficient and sustainable learning environments.

Currently, Albania's schools—particularly those in rural areas—suffer frequent power outages because they have limited access to a national electric grid that manages only a 60 percent reliability rate. Overall, however, the school buildings themselves have foundations that are well-suited to energy efficiency with some basic modifications. While major improvements are needed in some areas to make the schools both energy efficient and compliant with Albania's new EU-based standards for educational facilities, if implemented properly, the amount of resources needed to power the schools will be significantly lower than would be used by standard building renovations.

With that in mind, the ASU research team conducted a comprehensive study, which involved a literature review; software-based modeling for various energy, comfort, and impact scenarios; cost-data gathering and analysis; and evaluations of the results. The study is detailed in the following report.

### Overview

Based on Albanian government financial resources and the evidence that emerged from this study, ASU researchers and local partners developed multi-tiered intervention options, which have the potential to transform energy efficiency and education in Albania's schools (see Table A, next page). The four tiers represent differing levels of green improvements that can be made to Albania's schools; each tier builds on the previous tier and involves a greater investment of resources with each gradation.

Tier 1 involves repairs to existing school buildings in order to eliminate moisture and mold. Tier 2 focuses on adapting school buildings to include passive energy efficiency—that is, non-mechanical improvements, including insulation and more energy-efficient windows; these can dramatically improve comfort levels with virtually no increase in energy use. In Tier 3, schools

would add energy-efficient heating systems (Tier 3A) and solar photovoltaic (PV) rooftop technology (Tier 3B), which is highly suitable for infrastructure integration because of its point-of-use electricity delivery mechanism. Finally, in Tier 4, schools would expand to include more classrooms and other instruction areas that will enhance the teaching of sustainability-infused curricula.

*Table A: Tiers of Recommended Green Improvements to Albania’s Schools*

Tier of Improvement	Brief Summary of Recommended Improvements
Tier 1	<b>Repairs:</b> Eliminate moisture and mold; repair existing systems
Tier 2	<b>Passive Energy Efficiency:</b> Add passive energy efficiency and water harvesting measures
Tier 3	<b>Heating and Solar PV:</b> Add heating systems, fans and LED lights (Tier 3A); Add rooftop solar photovoltaic (PV) renewable energy (Tier 3B)
Tier 4	<b>Green Facility Additions:</b> Add more classrooms and specialized instructional spaces

## Recommendations

Findings generated through ASU’s methodology demonstrate that the following strategies and actions have the potential to improve the learning environment by ensuring reliable electricity, greater comfort, and healthier conditions in Albania’s schools. Over the long term, this type of widespread change can contribute to a stronger education system, employment generation, a new clean energy sector, increased GDP, and a position at the forefront of the global green schools movement.

- **Implement a pilot program of improvements in a nationally representative sampling of school buildings.**
  - An ideal sampling would be representative of (a) the two identified building types; (b) the three identified climate zones: (1) field Mediterranean, (2) hilly and pre-mountainous Mediterranean, and (3) mountainous Mediterranean; and (c) urban-versus-rural settings. To maintain a manageable sample size, this study suggests selecting three school buildings per scenario, for a total of 36 buildings.
  - Set a minimum target of Tier 2 improvements for the pilot schools with a goal of implementing through Tier 4 improvements on at least twelve of the schools—one representing each combination of building type, climate zone, and setting.
  - Select pilot schools to be geographically dispersed throughout the country in order to benefit a wide range of areas and better understand the impacts of urban-versus-rural settings on costs and procedures. These pilot projects can serve as demonstration projects to train contractors, architects, inspectors, students, teachers, and directors.
- **In partnership with the Ministry of Health, Social Welfare and Youth, initiate the phased development of a domestic solar PV industry.**
  - To expand current capacity, develop a training program for vocational and adult education schools, using schools sponsored by the Ministry of Education and Sports as the initial “customers.”

- **Require all new schools be built to Tier 4 standards.**
  - New schools should be designed and built to achieve maximum energy efficiency then used as models for contractor training and stakeholder awareness. The newly completed Hyseh Cela Durres vocational school is an example that demonstrates the domestic construction expertise needed to achieve a green school system moving forward.
- **Develop a scaling plan based on funding availability and lessons learned in the pilot phase.**
  - If sufficient funding is available to execute the multi-tiered implementation approach outlined here, ASU recommends an evaluation of the following scaling options:
    1. Improve all schools to an achievable tier, keeping in mind that Tier 2 provides a high cost-to-value ratio.
    2. Work on schools that are most in need first, improving them to the highest tier possible based on case-by-case evaluations.
    3. Make different improvements from different tiers selectively, keeping in mind the safety and cost issues related to sequencing (as described in this report).

Figures A (below) and B (next page) illustrate the transformation of an existing building to an energy-efficient, green building achieved through a Tier 4 level of improvement.



*Figure A: Typical Gymnasium School in Existing Condition*



*Figure B: Typical Gymnasium School with Tier 4 Improvements*

## Outcomes and Impact

Arizona State University estimates that transforming Albania's 3,327 schools into regional and global green school leaders will generate the following benefits over the short, medium, and long term. Timing and sequencing will depend on the scaling strategy implemented.

### Short Term

- 220,000 jobs created.
- Classrooms that provide greater comfort, better indoor air quality (by eliminating mold and moisture), and better lighting (particularly early and late in the day).
- Schools equipped with laboratories, athletic facilities, and more classroom space per student.
- Curriculum opportunities for incorporating energy and sustainability education.

### Medium Term

- US\$880 million increase in GDP.
- Decreased student and teacher absenteeism from illness.
- Increased student attention span and improved learning outcomes.
- Energy consumption and carbon dioxide emissions that are 56 percent lower than if school buildings were renovated using standard ("non-green") methods.

### Long Term

- Higher level of education achieved, leading to a more educated workforce and new economic opportunities.
- A national solar PV industry able to spread to a private-sector client base.
- Sustainability-based economic leadership in the region.

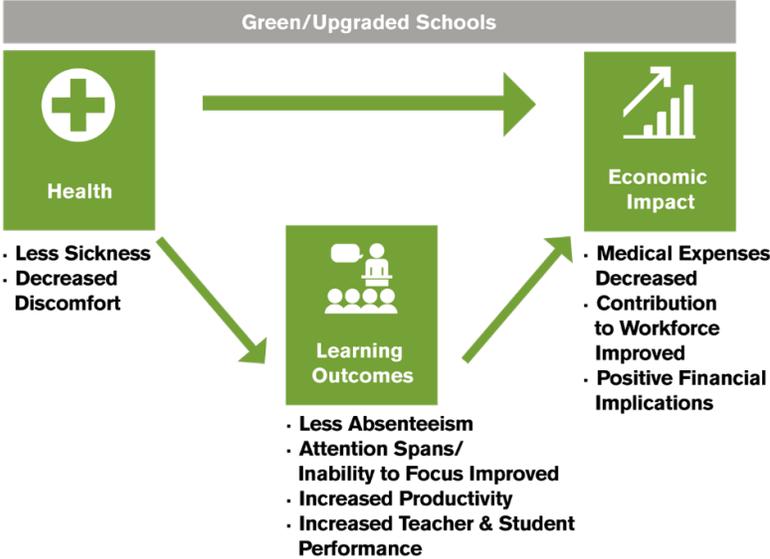
The cost for achieving Tier 2 improvements—the minimum target recommended by ASU—is approximately \$205 million. The cost for implementing all four tiers is estimated at \$1.33 billion, which averages out to an investment of approximately \$2,150 per student. This will bring Albania’s schools up to and beyond the standards of most developed countries. Costs and the benefits that can be expected from them are summarized in Table B.

*Table B: Summary of Investments and Impacts from Green Improvements to Albania’s Schools*

Tier	Construction Costs (US\$, million)	Annual Comfort (%)	Annual Energy Usage Increase (kWh)	Annual Energy Cost Increase (US\$)	Annual CO <sub>2</sub> Emissions Increase (Metric Tons)	Employment Opportunities Generated	GDP Increase (US\$, million)
1	\$174.91	55	2,880,759	\$244,000	29.09	28,386	\$113.48
2	\$29.98	79	27,968	\$2,369	0.28	9,129	\$36.49
3 (A+B)	\$111.93	97	23,451,513	\$1,986,343	236.83	18,164	\$72.61
4	\$1,014.18	N/A	N/A	N/A	N/A	164,588	\$657.97
Total	\$1,331.01	N/A	26,360,240	\$2,232,712	266.2	220,267	\$880.56

*Note: Energy and comfort modeling was only completed for Tiers 1–3 in the three climate zones so is not applicable in Tier 4.*

From an economic investment standpoint, green schools stand out for both their immediate and long-term impact, including jobs and economic stimulus. Benefits also include equipping students with the educational skills to improve their lives and the Albanian economy while integrating into the European Union and solving domestic, regional, and international sustainability challenges. The qualitative benefits of these improvements are summarized in Figure C.



*Figure C: Positive Links between Health, Learning Outcomes, and Economic Impact*

# Main Report

## Objective

The objective of this study, *Green Energy-Efficient Schools for Albania*, was to provide Albania’s Ministry of Education and Sports (MOES) with information on the benefits and costs of improving Albania’s public schools for energy efficiency and green characteristics, as well as information on how green schools can be used in a sustainability-oriented curriculum. Funded by the Open Society Foundation for Albania, which pursues democratization and EU integration, the project involved executing the following contracted tasks:

- Task 1: Analyze financial costs and benefits of energy-efficient green schools.
- Task 2: Analyze the impact of green school environments on learning outcomes.
- Task 3: Evaluate green facilities as teaching tools.
- Task 4: Analyze potential emissions avoidance and environmental benefits.

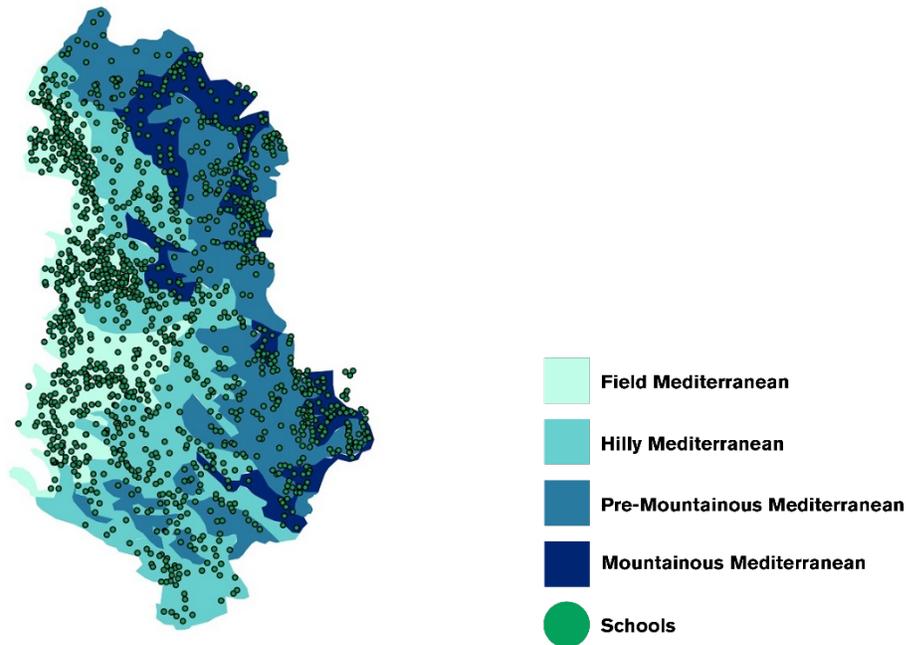


Figure 1: Albania’s School Locations by Climate Zone

The Walton Global Sustainability Solutions Services of the Julie Ann Wrigley Global Institute of Sustainability at Arizona State University implemented the project from July 2014–May 2015 using an interdisciplinary team of expert faculty, staff, and students from various fields, including sustainability, architecture, construction, engineering, education, economics, geographical information systems, visual arts, and project management. The project was also made possible by invaluable data input and logistics assistance from the Albanian Ministry of Education, the East-West Management Institute, school directors, and staff. Support on local pricing information was provided by both Arizona contractors and engineers and Albanian architects and contractors.

## Framework of Project Approach

Retrofitting existing schools for energy efficiency and green features provides many known and hypothesized benefits, attributable to the schools, as well as from the retrofitting process. Construction projects create jobs and positive economic impacts. The approach taken in this study focused on the following quantitative and qualitative benefits and costs:

### Benefits:

- 1) Energy savings (quantitative)
- 2) Generated construction jobs and construction-related jobs (quantitative)
- 3) Increased economic activity (quantitative)
- 4) Improved learning outcomes (qualitative)
- 5) Improved student and teacher health (qualitative)

### Costs:

- 1) Construction costs (quantitative)

With considerable effort, it was possible to make quantitative estimates of energy savings, construction costs, resulting jobs, and economic impact. Literature shows that green buildings and schools improve productivity, learning outcomes and building occupant health, and it is known that these outcomes have a corresponding positive impact on the economy. However, a lack of Albania-specific data associated with these topics (such as daily student attendance statistics) and the margin for error in statistically linking green schools to improved learning outcomes and health and then to national economic output suggested that a qualitative analysis was more appropriate for looking at those benefits.

## Why Green Schools?

The ultimate goal of creating green schools that also incorporate sustainability into their curriculum is to produce graduates with the skills and know-how to improve their lives and Albania's economy while caring for the planet. While the data and research are insufficient to connect these ultimate outcomes quantitatively, the research literature implies the likelihood of achieving these outcomes by developing a green educational system that addresses curriculum and campus improvements.

## Research Literature on the Impact of Green School Environments on Learning Outcomes

Green schools not only aim to reduce operating costs and improve energy efficiency, but also aim to enhance productivity and improve the health and well-being of occupants according to Massachusetts Technology (MASSTECH) (Okcu et al. 2011). The on-site assessment of the Albanian school's facilities indicated potential positive impacts from incorporating green school designs as well as from updating and better maintaining school facilities in five key areas: (1) indoor air quality (IAQ), (2) thermal comfort, (3) mold and moisture, (4) ventilation, and (5) lighting. An extensive literature review of these topics provided insight into understanding how energy-efficient green features and better school maintenance could impact learning outcomes and improve student and teacher health.

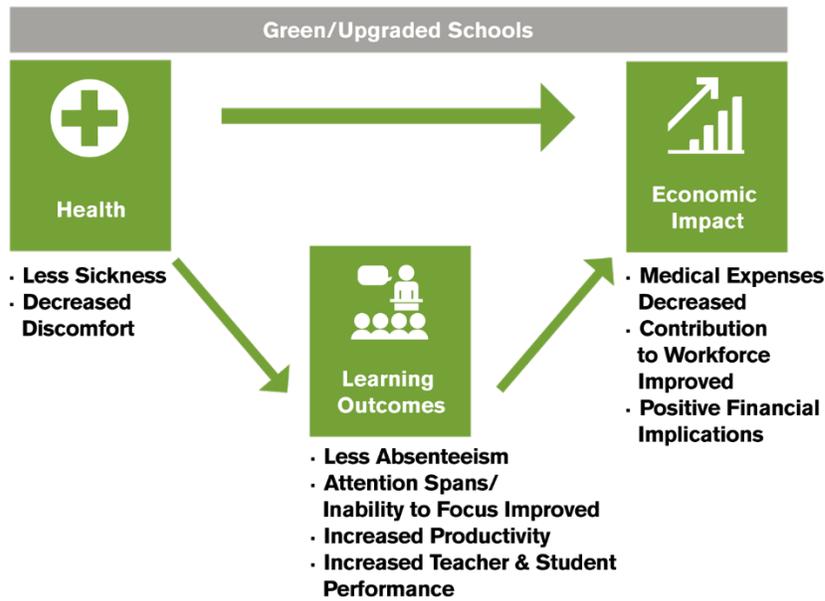


Figure 2: Summary of Positive Links between Health, Learning Outcomes, and Economic Impact

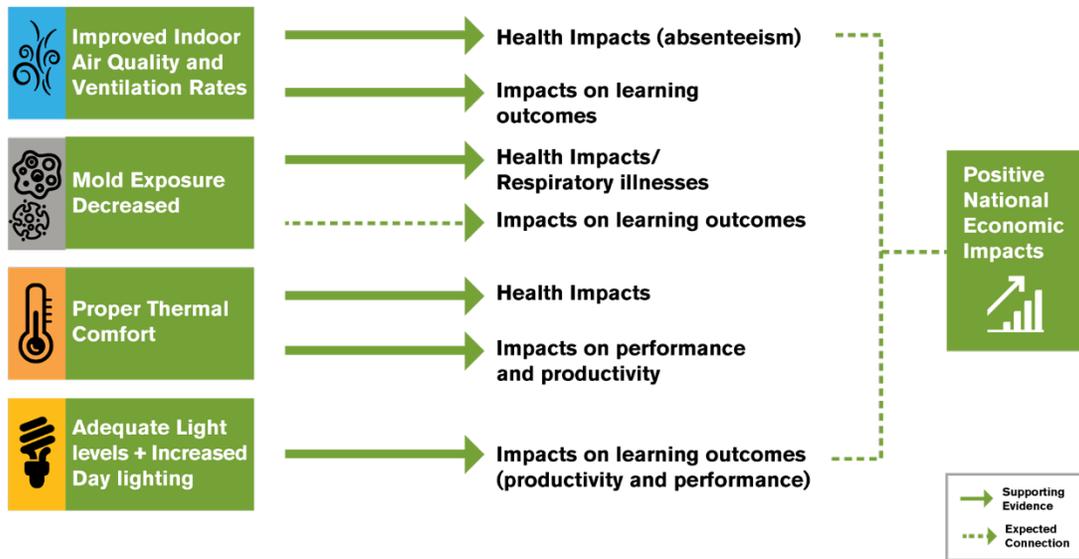


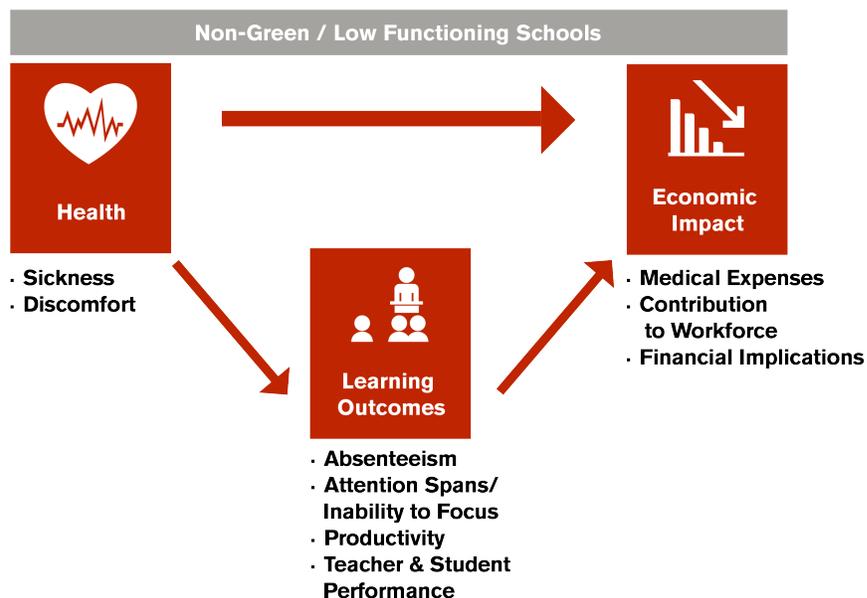
Figure 3: Summary of Research Findings Related to Green-School Characteristics, Learning, and Health in Schools

Studies found that schools with green features led to a:

- 12 percent decrease in missed work days for teachers,
- 15 percent decrease in absenteeism, and

- 19 percent increase in overall verbal and reading scores (Okcu et al. 2011).

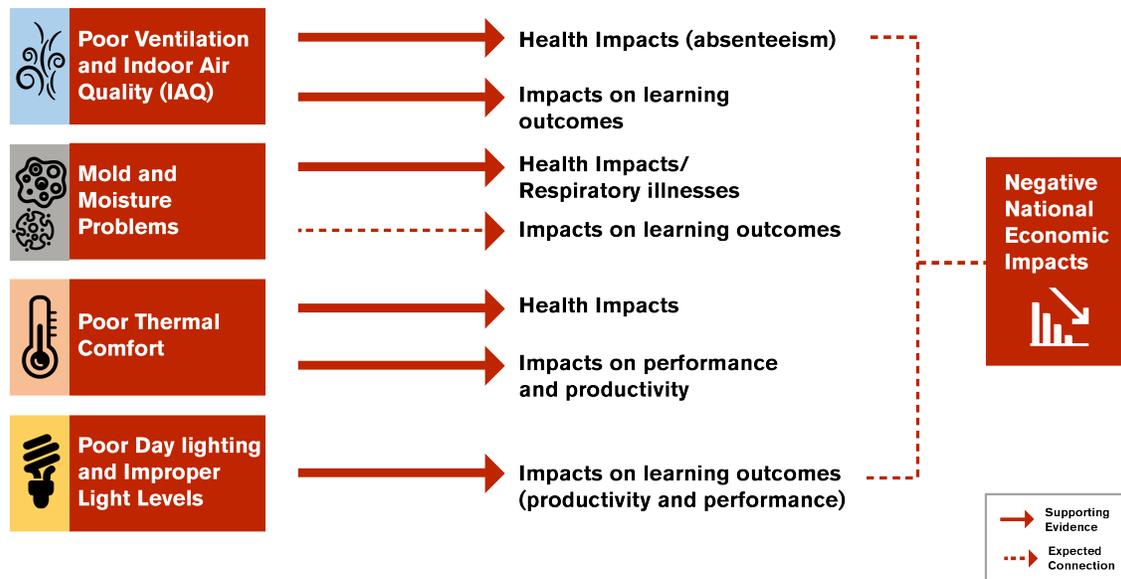
Research on school lighting provided evidence that improvements to this area can enhance visual and nonvisual outcomes in students from healthy eyesight to higher achievements (Okcu et al. 2011). There was also evidence showing an inverse relationship with productivity and an increase in thermal comfort. One experimental study found that a nearly 4 degree Celsius decrease in temperature resulted in an increase in logical thinking, as well as an improved performance in subtraction and reading (Okcu et al. 2011). Higher temperatures also have the potential to increase the growth of some biological pollutants such as mold (Ghodrati et al. 2012).



*Figure 4: Summary of Positive Links between Health, Learning Outcomes, and Economic Impact*

Poorly maintained and outdated buildings present health and productivity issues for occupants via poor indoor air quality, thermal comfort, ventilation, mold and moisture problems, and improper lighting levels. Research suggests that building deficiencies related to temperature, comfort, age, acoustics, and lighting have a direct negative impact on student performance (Earthman 2002). Occupancy density—that is, overcrowding—air filtration, ventilation, temperature, and humidity can increase the chances of contracting infectious diseases such as the common cold, influenza, and other common respiratory illnesses, which leads to higher costs of healthcare, increased absenteeism, and loss of productivity (Fisk 2000). Thermal discomfort can impact productivity as temperatures exceeding optimal conditions—including those that are either too cold or too hot—correlate with low levels of manual dexterity, headaches, lethargy, and negative impacts on mental performance (Wyon 2004). Similarly, research completed in business centers in Europe and the tropics indicate that worker productivity declines as poor indoor air quality (from pollutants, moisture, or other contributing factors) increases. Research also consistently indicated negative health impacts from high mold and moisture content at schools (Taskinen et al. 1997). These findings suggest that Albanian

children facing similar poor indoor-air-quality conditions could see decreased academic performance as well as negative health impacts.



*Figure 5: Summary of Research Findings Related to Green-School Characteristics, Learning and Health*

The literature review suggested that there is great potential to improve student learning outcomes and student and teacher health by upgrading to green schools in Albania. Such improvements can be directly tied to better indoor-air quality, increasing thermal-comfort levels, eliminating excessive mold and moisture, increasing ventilation rates, and improving lighting levels and quality. These benefits will impact the classroom and also have the potential to impact local economies.

### Research Literature on Green Schools and Sustainability Education

Green schools have the ability to enhance learning outcomes and improve productivity among students and teachers, but they can also serve as springboards to shape the behavior of students now and as future leaders of their communities. Green schools incorporate changes to facilities as well as interweaving “green teaching” into classrooms and the community. An extensive literature review focused on teaching sustainability and energy concepts provided insight into effective classroom teaching methods for these fields and how facilities themselves have been used as educational tools.

The green schools movement is one manifestation of sustainability education gaining popularity in recent years. For example, the US Department of Education has established a “Green Ribbon” schools program to encourage schools to think more broadly about integrating sustainability across their curriculum, campus, and community with sustainable solutions focused on healthy environments, population wellness, and economic efficiency (Warner and Elser 2015). Some characteristics of green schools in the United Kingdom include being: (1)

resource efficient; (2) physically and psychologically healthy; (3) comfortable, responsive, flexible; and (4) based on ecological principles (Edwards 2006).

Education for sustainability (or education for sustainable development) is defined more broadly than “environmental education” to include issues of international development, economic development, cultural diversity, social and environmental equity, and human health and well-being (NSCE 2003). For about the past decade (2005–2014), the United Nations, via UNESCO, has led an international effort to use education as a driver of change in order to address the social, economic, cultural, and environmental issues that are faced in the twenty-first century (UNESCO 2014). A school incorporating sustainability education should connect students with their environment and their community by promoting community service in environmental stewardship and engaging students in long-term sustainability projects. Schools should model sustainability through their facilities, culture, personal relationships, and community involvement (NSCE 2003). Interviews with Albanian school directors and teachers indicated that many schools have started to incorporate some of these best teaching practices into their curriculum. Examples from Albanian schools included bringing in community members to engage students on local environmental issues, participating in local clean-up projects, and conducting nature studies.

Energy education is a subset of the larger sustainability education movement. Energy topics are typically found associated within science curriculum and standards. Research on student understanding of energy shows that students have great difficulty understanding the concept of energy in general, and energy types and transfer more specifically (Kesidou and Duit 1993). By focusing on real energy systems while current school facilities are upgraded, students will be provided an opportunity to understand local energy systems while learning energy concepts. Research suggests that such students will become “energy literate” and empowered to become engaged in objectively assessing energy-related decisions throughout their daily lives (DeWaters et al. 2013).

One aspect of the green schools movement has been for educators to use the facilities themselves as teaching tools. The most common curriculum integration is using the school-grounds through schoolyard ecological/nature studies, outdoor adventure education, community projects, and schoolyard gardens. Schoolyard gardens have been particularly well studied and found to increase student achievement in the areas of science and food behavior (Blair 2009). Other aspects of incorporating green schools facilities—such as additions of solar panels, water harvesting, working toward LEED certification and place-based and contextual learning—are not as common, but there is evidence that more schools are using them within their curriculum (Gordon 2010). At several of the Albanian schools visited, schoolyard gardens (and even just-potted plants) were being incorporated into the curriculum. The main benefit of using the green school grounds and facilities for learning is in providing students with more meaningful contexts for learning, but it also requires support from school administration and inclusion of this type of learning within the academic standards (Dyment 2005).

Kensler (2012) summarizes a variety of green-school research suggesting that school leaders incorporating sustainability practice will reap financial benefits without investing large sums of money in new designs and technology. Green schools also lead to opportunities for student

learning that are place-based, relevant, and meaningful. This research suggests that students in green schools are engaged in learning and achieving at high levels. With Albania incorporating new teaching standards and improving school facilities, including solutions-oriented sustainability education could enhance Albanian students' abilities to solve complex problems today and in the future.

## Analysis Results

### Current Conditions

In general, Albania's schools were well-designed for their time, incorporating abundant daylight, outdoor views, and solid passive thermal mass construction. These are highly valuable green-building strategies that should be celebrated and preserved. The major facilities challenges are moisture-related construction defects; broken mechanical, electrical, and plumbing systems; overcrowding; and a lack of specialty instructional space (such as science laboratory classrooms). Humidity and mold are pervasive because of water-wicking slabs and walls, and in some instances leaky roofs.



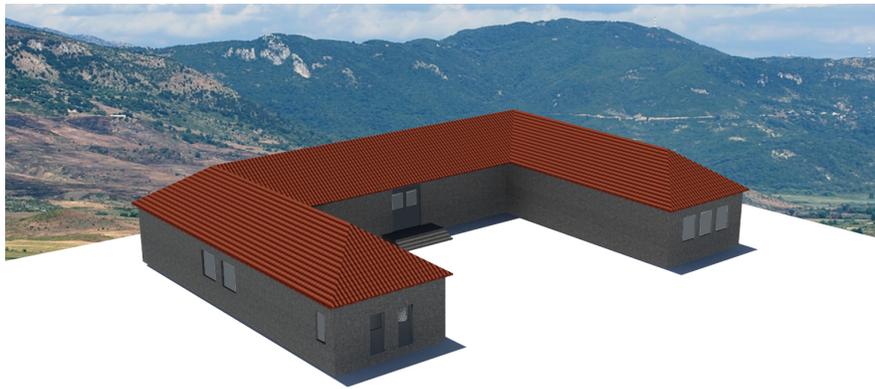
Figure 6: Representative Albanian Schools (from Site Survey)

### Improvement Options

In order to provide maximum fiscal and strategic options for the Ministry, the ASU team developed two models (condensed from three original models) to represent general types of Albanian schools, and four sequential tiers of potential green improvements for each. Those improvements are very briefly summarized in the following table and images:

*Table 1: Tiers of Recommended Green Improvements to Albania's Schools*

Tier of Improvement	Brief Summary of Tier Improvements
Tier 1	<b>Repairs:</b> Eliminate moisture & mold and repair existing systems
Tier 2	<b>Passive Energy Efficiency:</b> Add passive energy efficiency measures (including insulation and more energy-efficient windows) and water harvesting
Tier 3	<b>Heating and Solar PV:</b> Add heating systems, fans, LED lights (Tier 3A) and rooftop solar photovoltaic renewable energy systems (Tier 3B)
Tier 4 (green facility additions)	<b>Green Facility Additions:</b> Add more classrooms and specialized instructional spaces



*Figure 7: Type 1 School in Existing Condition*



*Figure 8: Type 3 School in Existing Condition*

With some exceptions, Albanian schools in their existing conditions have had virtually no major improvements since their original construction, which means an average of twenty years without improvements.



*Figure 9: Type 1 School with Tier 1 improvements*



*Figure 10: Type 3 School with Tier 1 improvements*

In Tier 1, improvements aim to eliminate moisture and mold and repair existing systems, also adding new space for toilets, mechanical equipment, and stairs for fire-safety evacuation purposes.



*Figure 11: Type 1 School with Tier 2 Improvements*



*Figure 12: Type 3 School with Tier 2 Improvements*

Tier 2 improvements add passive energy-efficiency features to increase thermal and visual comfort, rainwater harvesting equipment, and interior fans for summer cooling.



*Figure 13: Type 1 School with Tier 3 Improvements*



*Figure 14: Type 3 School with Tier 3 Improvements*

In Tier 3, heating systems for winter comfort, LED lights, and rooftop solar photovoltaic (PV) renewable energy systems are added.



*Figure 15: Type 1 School with Tier 4 Improvements*



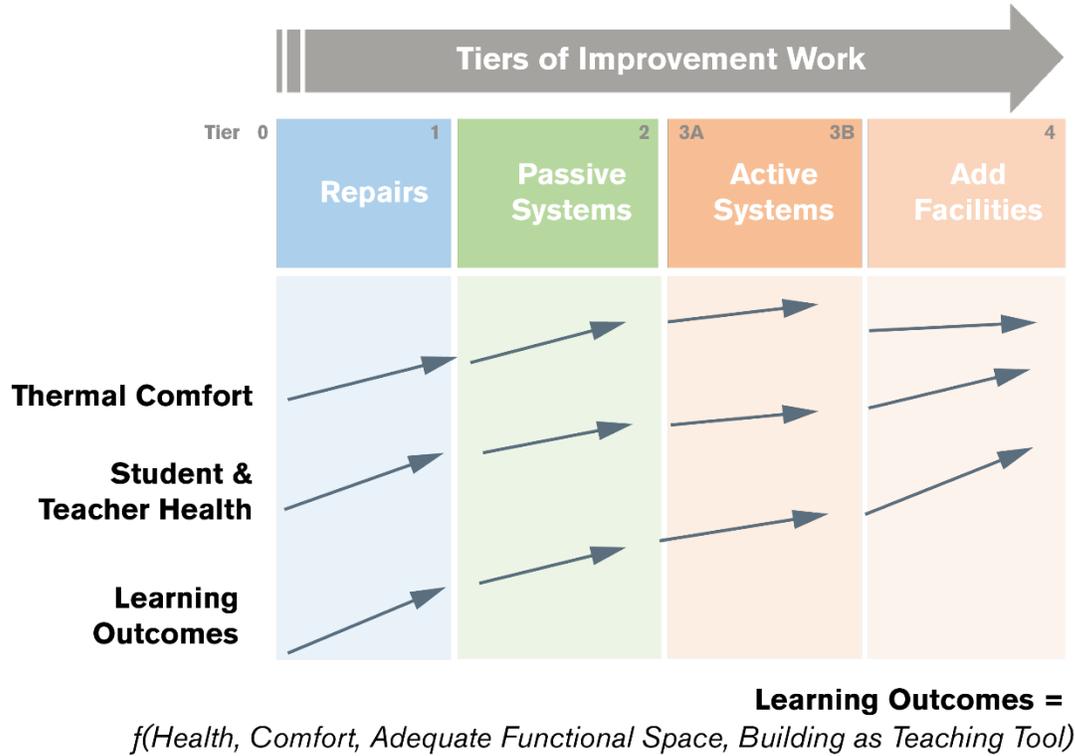
*Figure 16: Type 3 School with Tier 4 Improvements*

Tier 4 improvements add more classrooms and specialized instructional spaces, as well as site development for athletics and learning gardens

Note that with historical population growth, Tier 4 improvements bring Albanian schools into compliance with the Albanian government's student occupancy space standards, which require, at a minimum, less space per student than US standards.

## Benefits Summary

Improving Albania's schools potentially creates many benefits, which are summarized in the illustrations below and explained in the following sections.



*Figure 17: Summary of Potential Qualitative Benefits Related to Tiers of Improvements*

From a qualitative standpoint, progressive tiers of improvements are expected to result in progressive increases in benefits in thermal comfort, student learning outcomes, and student and teacher health. The strongest increases in benefits are expected in the first and fourth tier, with the exception that thermal comfort is not expected to change between the third and fourth tier. However, physical comfort should increase considerably in the fourth tier as additional space, athletic facilities, and other facilities are added.

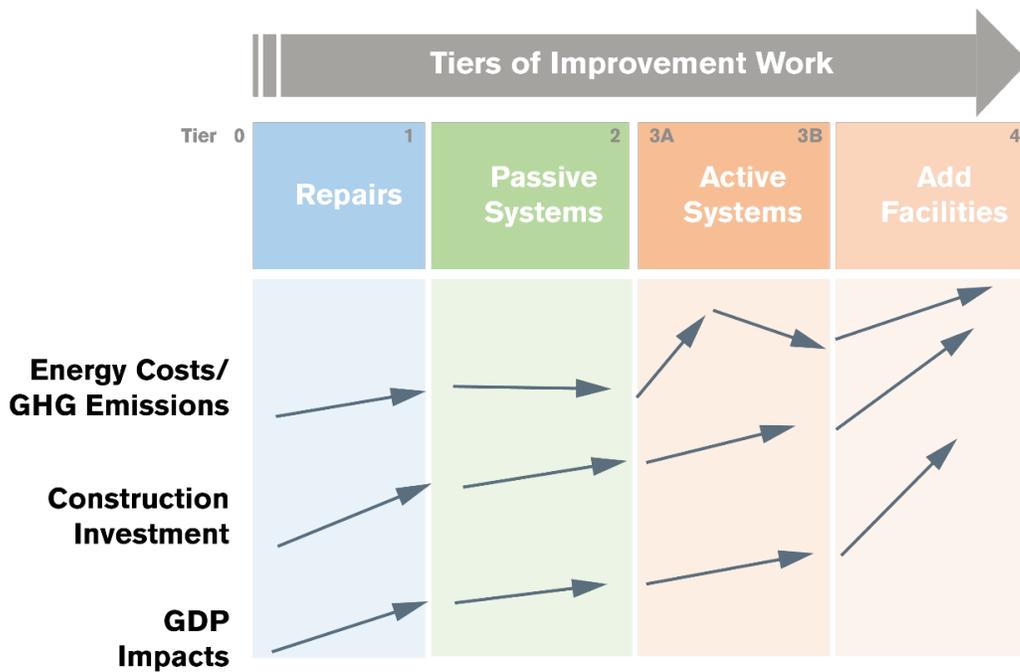


Figure 18: Summary of Predicted Quantitative Benefits Related to Tiers of Improvements

From an economic standpoint, gross domestic product (GDP) impacts are expected to cumulatively grow as construction investment grows, with strong impacts in Tier 1 and very strong impacts resulting from the extensive Tier 4 improvements. As school equipment and electrical systems are repaired in Tier 1, energy use and CO<sub>2</sub> emissions are expected to increase. Tier 2 passive-comfort improvements leave energy use essentially unchanged. Implementing heating systems in Tier 3 to further improve comfort for the winter months is expected to dramatically increase energy use and emissions but much less than if Tier 2 improvements had not been implemented. Also installing solar photovoltaic systems in Tier 3 further offsets that rise. Adding extensive additional facilities in Tier 4 will again raise energy use, but building those facilities to be energy efficient means maintaining or even reducing energy use per square meter of total school floor space.

### Comfort Benefits

Beyond the critically important reduction in humidity and elimination of mold suggested for Tier 1 upgrades, thermal comfort in the schools could be improved dramatically through Tier 2 and Tier 3 upgrades. The two school types were modeled in three climate zones: field, mountainous, and hilly/pre-mountainous. (Technically, the latter are considered separate climate zones in Albania, however these were combined for analysis purposes). Due to current limitations in modeling software, it is not feasible to model buildings that are significantly open to the outdoors—including those that are open deliberately or those with broken windows—so comfort was evaluated starting at Tier 1. The graph below illustrates the average percent of comfortable students inside the classroom—estimated using results from various modeling systems (see “Modeling Energy and Comfort Impacts” section)—by tier and climate.

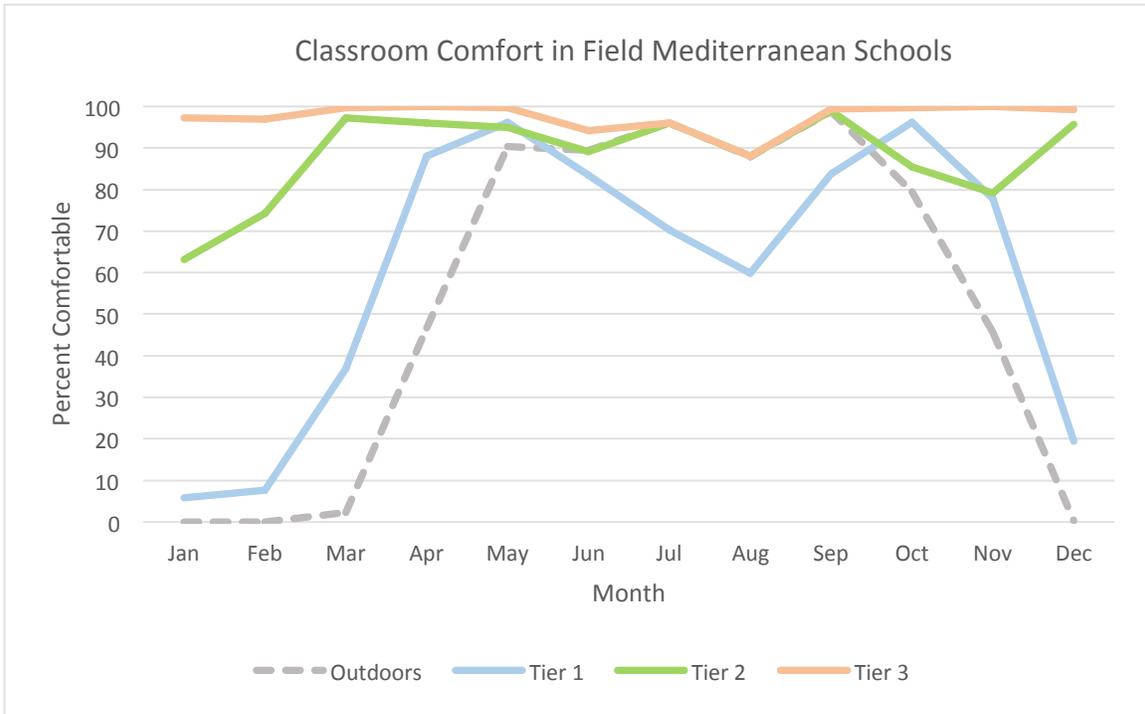


Figure 19: Classroom Comfort in Field Mediterranean Schools

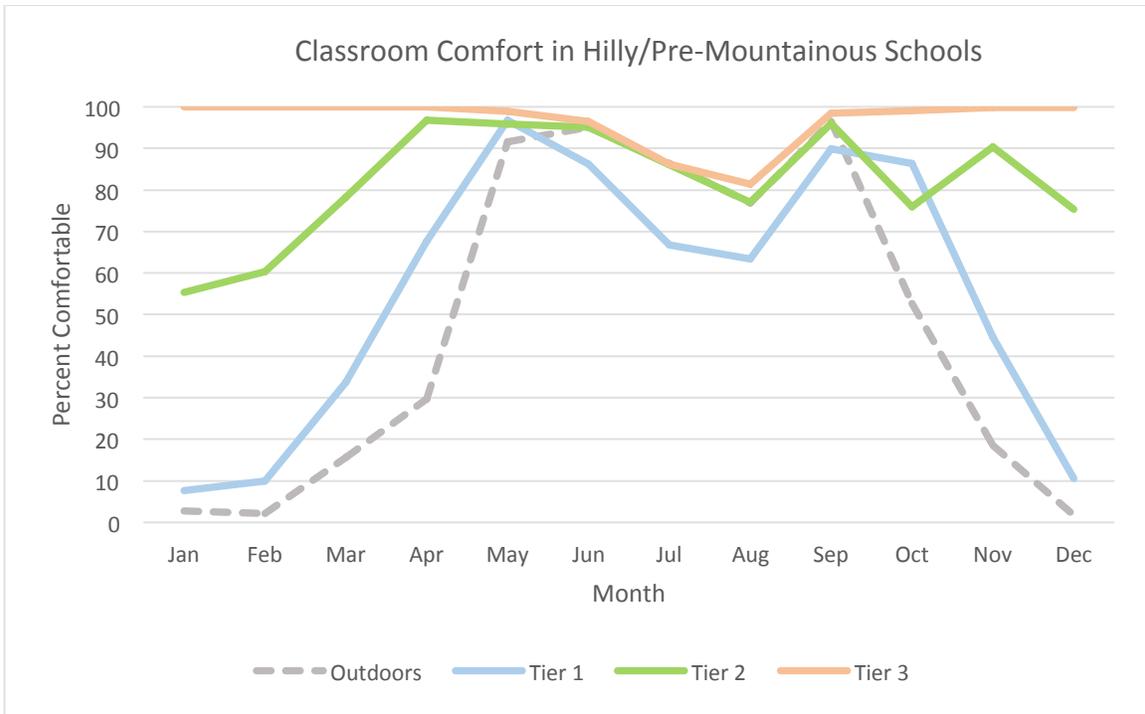


Figure 20: Classroom Comfort in Hilly/Pre-Mountainous Schools

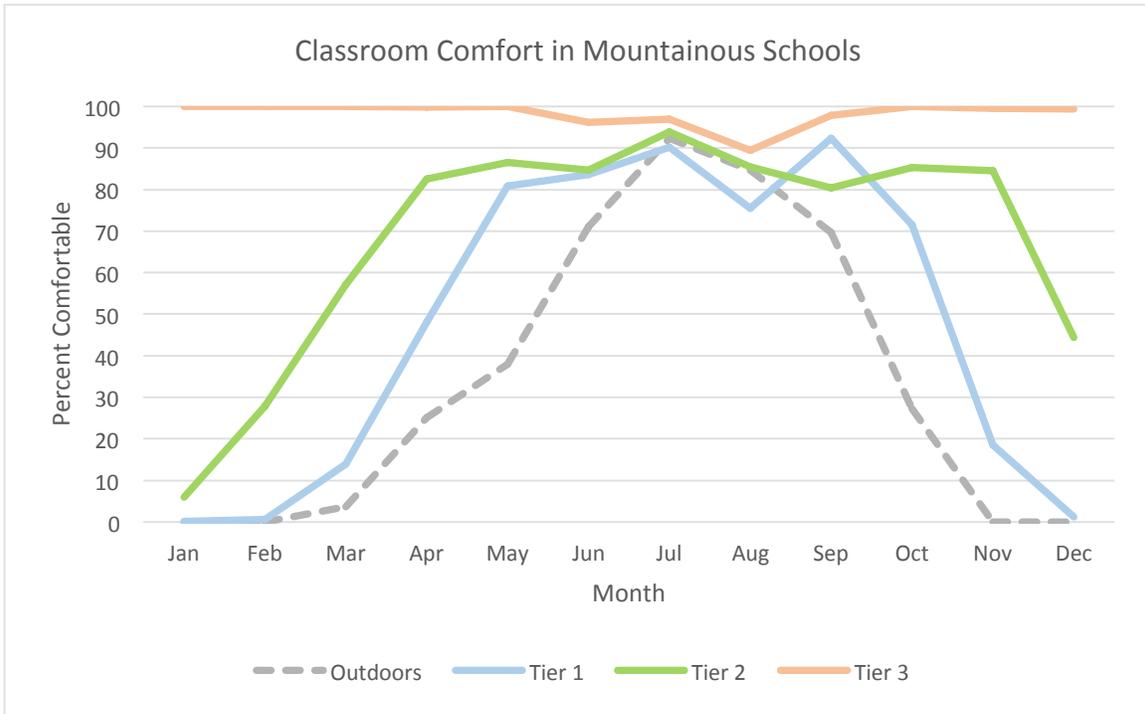


Figure 21: Classroom Comfort in Mountainous Schools

Analysis shows that winter months still pose comfort issues in the mountainous and hilly/pre-mountainous climate zones in the Tier 2 scenario as heating systems are not added until Tier 3. However, cost estimates indicate Tier 2 improvements to have a very strong comfort return per unit of cost. Cooling is not deemed to be needed in any of the climate zones once Tier 2 exterior insulation is implemented. Comfort was modeled with the assumption that windows would be opened and wall-mounted classroom fans used as appropriate during mild weather months.

### Energy Benefits

Before the start of this study, it was hypothesized that energy savings captured over time through energy efficiency improvements would contribute to paying for the costs of those improvements. However, site visits indicated that schools currently use very little energy due to some combination of broken mechanical and electrical systems, broken equipment, and/or a lack of fuel-to-power systems. So, as school improvements dramatically increase comfort and school functionality, energy use will also increase, though by significantly less than would otherwise have been the case if energy-efficiency strategies were not a primary focus. Below are the energy consumption changes expected from the implementation of Tiers 1–3.

Table 2: Annual Energy Change

Tier of Improvement	Type 1 schools (n=3215)		Type 3 schools (n=112)	
	Energy use kWh/year	Energy cost USD/year	Energy use kWh/year	Energy cost USD/year
Tier 1 (repairs)	2,435,725	\$206,306	445,034	\$37,694
Tier 2 (passive energy efficiency)	23,694	\$2,007	4,274	\$362
Tier 3A (heating)	24,336,921	\$2,061,337	5,313,453	\$450,049
Tier 3B (solar PV)	(4,873,284)	(\$412,767)	(1,325,577)	(\$112,276)
<b>Total</b>	<b>21,923,057</b>	<b>\$1,856,883</b>	<b>4,437,185</b>	<b>\$375,830</b>
Total Tier 1 + 3 (kWh/year)	26,360,241			
Total Tier 1 + 3 (\$/year)	\$2,232,712			

Note: Decrease indicated in red.

This analysis indicates that Tier 2 passive energy efficiency improvements result in essentially no increase in energy use while dramatically improving student and teacher comfort (Figure 23). Also note that Tier 3 improvements have been separated to highlight the significant energy-use increases due to the addition of heating systems in all climates (Tier 3A) and complementary energy-use reductions captured by adding solar photovoltaic (PV) panels to the roofs (Tier 3B). For this analysis, the PV system on the Type 3 schools was sized only large enough to meet the energy needs of the lowest demand month in order to avoid generating excess energy during certain months and sending that energy back to the electricity grid. Type 1 schools do not have enough roof space to generate enough electricity to meet 100 percent of school needs (with heating) in any months of the year, although ground-mounted solar PV arrays are an option.

Note also that the annual energy needed to operate the schools in Tier 3 with heating systems in the winter would be substantially higher (roughly 57 percent higher or 15,099,244 kWh per year) if the Tier 2 energy-efficiency measures were not first installed.

Additionally, creating energy models for Tier 4 school additions was beyond the scope of this analysis, but high energy-efficiency standards for new construction would minimize increases in energy use relative to the potential physical comfort and learning outcomes benefits gained by greatly expanding learning space and functionality of the schools.

### Construction Costs

Estimating and extrapolating construction costs across 3,327 buildings of various types and conditions in three climate zones in both urban and rural settings was a significant challenge. The ASU team integrated results from several standard cost estimating methods and reasonable assumptions to develop the following coarse estimates (in US\$).

*Table 3: Construction Costs by Building Type and Tier of Improvement*

<b>Tier of Improvement</b>	<b>Type 1 schools (n=3,215) Construction costs</b>	<b>Type 3 schools (n=112) Construction costs</b>
Tier 1 (repairs)	\$ 148,644,650	\$ 26,267,800
Tier 2 (passive energy efficiency)	\$ 25,387,527	\$ 4,596,865
Tier 3 (heating and solar PV)	\$ 96,164,875	\$ 15,760,680
Tier 4 (green facility additions)	\$ 961,648,750	\$ 52,535,600
<b>Total</b>	<b>\$ 1,231,845,802</b>	<b>\$ 99,160,945</b>

This analysis indicates that the low cost of Tier 2 improvements provides significant comfort benefits and essentially static operating costs. It should be noted that Tier 1 moisture-related improvements need to be accomplished before exterior insulation can be added in Tier 2.

### Economic Impacts

Beyond the impacts on the teaching and learning environment in the schools, greening Albania’s schools will generate significant economic impact. At present, a lack of data and research studies makes it impossible to quantify the positive economic impacts for Albania related to expected improvements in student educational outcomes. However, economic impact analysis centered on GDP, jobs, and labor income related to the investment in construction of the schools can be studied. Additionally, although somewhat less meaningful, output—the value of all goods and services produced in a region due to the investment (including intermediary goods and services)—is also presented. To accomplish these analyses, the ASU team created an economic impact model specific for Albania. This new model can also be used to analyze economic impacts of other investments in Albania.

Construction investment produces direct, indirect, and induced (spending by workers of their wages on other local goods and services) impacts. Significantly, the overwhelming majority of construction materials recommended are expected to be available from the domestic economy, increasing the positive economic impact of this project. Additionally, with development of a solar PV job training program, virtually all direct labor related to investing in Albania’s schools would accrue to the domestic economy, provided that sufficient local labor is available. The economic impacts of greening Albanian schools, due solely to construction investment, are as follows:

*Table 4: Economic Impacts of Albanian Green Schools Construction Investment (in US\$)*

<b>Tier of Improvement</b>	<b>Direct Effects</b>	<b>Multiplier Effects (indirect + induced)</b>	<b>Total Effects</b>
<b>Tier 1</b>			
GDP	\$51,608,661	\$61,869,108	\$113,477,769
Employment (# of jobs)*	16,347	12,039	28,386
Labor Income	\$29,615,823	\$22,457,029	\$52,072,852
Output	\$174,912,450	\$137,709,132	\$312,621,582
<b>Tier 2</b>			

<b>Tier of Improvement</b>	<b>Direct Effects</b>	<b>Multiplier Effects (indirect + induced)</b>	<b>Total Effects</b>
GDP	\$16,597,448	\$19,897,228	\$36,494,676
Employment	5,257	3,872	9,129
Labor Income	\$9,524,508	\$7,222,225	\$16,746,733
Output	\$56,252,192	\$44,287,531	\$100,539,723
<b>Tier 1+2</b>			
GDP	\$68,206,109	\$81,766,336	\$149,972,445
Employment	21,604	15,911	37,515
Labor Income	\$39,140,331	\$29,679,254	\$68,819,585
Output	\$231,164,642	\$181,996,662	\$413,161,304
<b>Tier 3</b>			
GDP	\$33,024,110	\$39,589,716	\$72,613,826
Employment	10,460	7,704	18,164
Labor Income	\$18,951,009	\$14,370,134	\$33,321,144
Output	\$111,925,555	\$88,119,348	\$200,044,903
<b>Tier 1+2+3</b>			
GDP	\$101,230,219	\$121,356,052	\$222,586,271
Employment	32,064	23,615	55,679
Labor Income	\$58,091,341	\$44,049,388	\$102,140,729
Output	\$343,090,197	\$270,116,010	\$613,206,207
<b>Tier 4</b>			
GDP	\$299,239,398	\$358,731,931	\$657,971,328
Employment	94,781	69,806	164,588
Labor Income	\$171,719,650	\$130,211,240	\$301,930,890
Output	\$1,014,184,350	\$798,470,584	\$1,812,654,934
<b>Tiers 1+2+3+4</b>			
GDP	<b>\$400,469,616</b>	<b>\$480,087,983</b>	<b>\$880,557,599</b>
Employment	<b>126,845</b>	<b>93,421</b>	<b>220,266</b>
Labor Income	<b>\$229,810,990</b>	<b>\$174,260,628</b>	<b>\$404,071,618</b>
Output	<b>\$1,357,274,547</b>	<b>\$1,068,586,594</b>	<b>\$2,425,861,141</b>

*\*Note: Employment is provided as the total number of fulltime-equivalent jobs created for one year.*

In a country with a large available labor pool, this economic analysis indicates that investment in greening Albanian schools would have large positive domestic economic ramifications.

### Greenhouse Gas Emissions Impacts

As the impacts of human-caused climate change become more pronounced and global efforts become more urgent, Albania has a particular interest in combatting this global phenomena. Recent flooding and fire events have illustrated the potential consequences of climate instability for Albanians (Associated Press 2015). To its advantage, Albania already generates 90 percent of its electricity from hydropower—a clean renewable power source (Islami et al. 2009). However, hydropower would be negatively impacted should climate change reduce rainfall in the region, as expected (Bruçi 2007). With abundant sunshine and a variety of climate zones, energy efficiency, solar PV and solar thermal represent strategic national opportunities to mitigate growth in CO<sub>2</sub> emissions as the nation’s economy grows.

Reusing existing school buildings as opposed to demolishing them and building new ones also produces a tremendous carbon benefit because of the embodied energy related to new construction. This embodied carbon is not accounted for in the CO<sub>2</sub> calculations below. An analysis of the greenhouse gas emissions impacts that result from Albania’s energy source mix and the changes in energy consumption of the schools at various tiers of improvement are illustrated below.

*Table 5: Change in Annual Emissions in Metric Tons CO<sub>2</sub>*

Tier of Improvement	Type 1 schools (n=3,215)	Type 3 schools (n=112)
Tier 1 (repairs)	24.60	4.49
Tier 2 (passive energy efficiency)	0.24	0.04
Tier 3A (heating)	245.77	53.66
Tier 3B (solar PV)	(49.21)	(13.39)
<b>Total</b>	<b>221.40</b>	<b>44.81</b>
<b>Total CO<sub>2</sub> Savings Tier 1 and 3</b>	<b>266.21</b>	

*Note: Decrease indicated in red.*

Note also that the annual carbon emitted from energy use in Tier 3B would be 56 percent higher, adding an additional 147.99 MTCO<sub>2</sub> per year) if the Tier 2 energy-efficiency measures were not first installed.

### Methodology

Based on the above approach, the team employed a methodology of parallel and sequential steps, as described and illustrated in Figure 22 (next page).

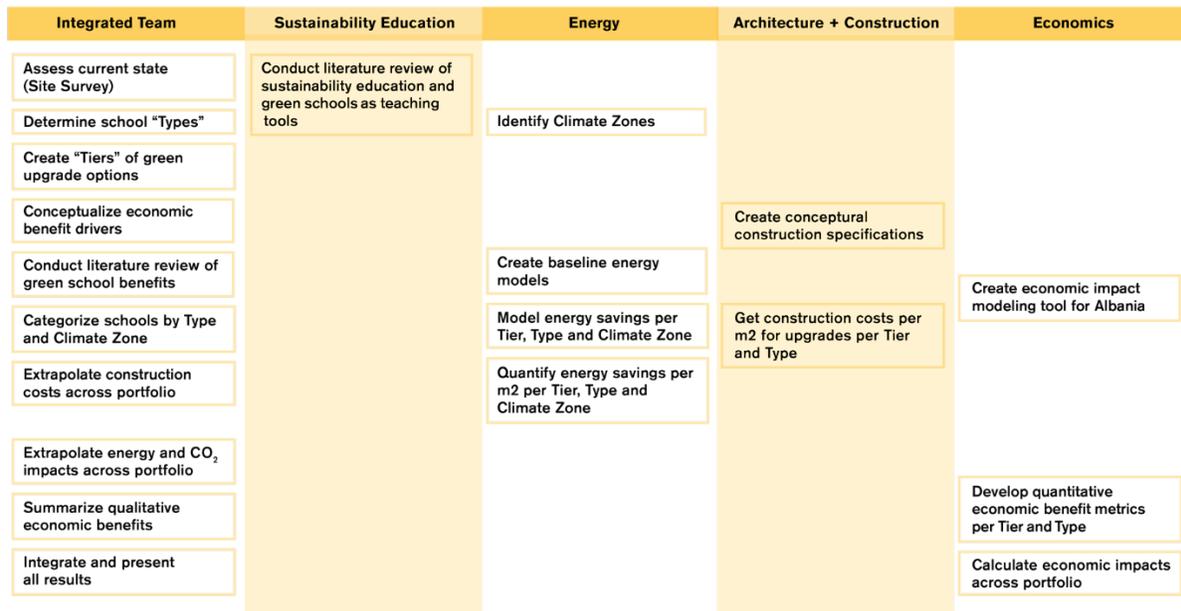


Figure 22: Albania Energy Efficient Green Schools Project Methodology

### Site Survey to Assess Current State of Albania's Schools

An expert site survey team was recruited and briefed for the study in early summer of 2014, with the physical survey visit implemented in early September 2014. The primary survey team was composed of Mick Dalrymple, practice lead and building energy efficiency expert; Lynette Pollari, RA, NCARB, sustainable schools coordinator and practicing architect; and Monica Elser, sustainability education manager and curriculum expert. The team was supported by Global Business Development Director Fron Nahzi, East West Management Institute Project Manager Delina Fico, Julie Ann Wrigley Global Institute of Sustainability Executive Director Rob Melnick, Albanian Ministry of Education and Sports staff, and Albanian English teachers as translators. This mix of experts afforded the project on-the-ground expertise in these important areas:

- Educational theory and delivery methods
- Green school design, construction, operations
- Building energy analysis and green-design practices
- Architectural needs assessment
- Benefit-cost analysis (BCA) study work
- Sustainability theory and practice

To prepare for the trip, available statistical documents on school infrastructure and planning studies provided by the MOES were reviewed by the team, including:

- Albanian Ministry of Education and Sports. 2012. *Guidance for Designing the School Building, Norms and Standards, Volume I, General Guidelines.*
- International Building Code. 2012. *Building Codes Illustrated, Volume 6: Building Codes Illustrated: A Guide to Understanding the 2012 International Building Code*, 4th ed. New York: John Wiley & Sons.

- European Commission, IFI Coordination in the Western Balkans, Western Balkans Investment Framework. 2012. *Financing Social Sector Projects in the Western Balkans Challenges and Opportunities for the WBIF*.
- Western Balkans Investment Framework. 2012. *Infrastructure Projects Facility in the Western Balkans: Support Albania's Ministry of Education and Science* to develop a management framework for investments in pre-university educational facilities (TA-ALB-10).
  - Initial assessment of current CIP-related management capacities, organizational processes, and decision-making frameworks within the Ministry of Education and Science (MoES). January 2011.
  - Assessment of Current IT Infrastructure at MoES (January 2011)
  - GIS Development Framework (February 2011)
  - Project update and issues arising (May 2011)

The team developed a site survey instrument to capture key data needs from the school visits. The team familiarized itself with MOES data, climate data, and cultural information. The team also communicated with the MOES team to design an itinerary for the site visits that would cover the most representative picture of existing building infrastructure conditions.

The September 15–18, 2014 site survey trip to Albania afforded the team a total of three days for visits to three different regions of the country to tour typical school buildings and campus settings. The first day of site visits was anchored in the Tirana area, representing the country's mild "field Mediterranean" climate zone. The second day was spent visiting schools south of Tirana including Mihajas and Krrabe in the higher elevation and cooler hilly Mediterranean climate zone. On the third day, the survey team traveled further west from Tirana to schools in the coastal area of Durres, a warmer version of the field Mediterranean climate zone. Across the three days, the team visited 13 schools with 19 buildings, spending time meeting with the school directors and touring and photographing the facilities. Assistants and translators (including school English language teachers) from the MOES traveled with the team to every site meeting, allowing for favorable conditions for interviewing school directors and staff.

Site visits provided the survey team with an overview of the country's climate zones and school building infrastructure. Ministry staff indicated that the 13 schools visited and inspected provided a reliable sample of the range of school types, ages, and conditions by region. Although the team did not visit any schools in the northern mountainous climate zone, it was the understanding that schools in Mihajas and Krrabe represented similar or the same construction types and systems to those in the mountainous regions.

On a fourth day, one team member separately visited two vocational school campuses consisting of eight buildings total. The construction and condition of seven existing buildings were consistent with what had already been surveyed. The eighth building was new and in the final days of construction. Funded by EU donors and built by an Albanian contractor, its energy efficient and green design and construction confirmed that Albania has the domestic construction capacity for such exemplary school buildings.

Following are some of the understandings the team gleaned from site visits:

- The portfolio of schools—from the 1940s to modern—employ **high mass construction**, providing an exemplary base for green-energy improvements and resource-efficient design; the buildings are typically built with concrete frames with concrete floors and roofs and brick masonry exterior and interior walls. They have many more years of available life as long as the building shells are repaired and improved to resist the elements, including water. **“Wet building syndrome” and the resulting mold and humidity is a major problem with all the buildings visited.**
  - One critical principle of sustainable design is reuse. The priority should always be on renovating or repurposing an existing structure before constructing new buildings, thus avoiding demolition, waste, and the need for all new materials.
- All the schools are **naturally well-lit during the day**, another key condition for energy-efficient design; even though many of the schools visited are challenged by an erratic municipal power supply that leaves schools without power for several hours per day, the day-lighting design allows for teaching without electrical lighting during daytime hours. Crowded schools running two shifts are challenged with darkness toward the end of the school day during the winter season.
- The schools represent **valuable historic building stock** that has not been altered. They can be considered historic properties representing two major architectural periods and styles:
  - Early modern (international 1940s modernism) design and construction for the larger buildings
  - Italian vernacular for smaller buildings, especially in the pre-mountainous and mountainous climate zones with hipped clay-tile roofs
- The schools create an opportunity for the Albanian Ministry of Education to take the solid, historic building stock and advance it into a sustainable future, without needing to endure the technological and architectural cycles of international school improvement and development, which have proven not to be particularly enduring or valuable to the future of learning (like using central computer laboratories versus portable laptop computers).
- Across the board, the survey team felt that the level of **energy and enthusiasm for education** evidenced from school directors, staff, and students is of great value to the MOES and Albania. In the simplest of educational settings, many times without operational lighting or working water/sewer systems, learning is underway in Albania’s classrooms with a level of commitment undaunted by challenging buildings and infrastructure.

### Building Systems Needing Repair

While the shells are solid, window systems are old, single-pane, and broken in many instances—leaving interiors open to the outdoor weather. Building insulation does not exist and historic clay-tile roofs need significant rehabilitation work to bring them into working condition, both for protection from the weather and to complete the thermal envelope. Mechanical, electrical, and plumbing (MPE) systems are rudimentary at best. The water and plumbing systems are limited to functioning European toilets. The aging electrical wiring and panel/service systems do not meet current international codes and standards, provide low capacity, and in many instances are unsafe with exposed wiring and switch boxes and lack of surge and

lightening protection. Lighting systems for classrooms tend to be either one to two incandescent bulbs hanging from the ceilings, or up to two fluorescent ceiling-mounted fixtures per room. Many classrooms do not have working lighting, and there is limited power for computer equipment. Any internet connections are generally via wireless technology. There are no central mechanical cooling systems and heating systems range from no heating system to wood burning stoves, especially for the smaller Type 1 mountainous schools. A few larger schools provide radiant heating from boilers.

### Defining School Building Types

Upon returning from the Albania school visits, the challenge for the ASU team was how to approach the impact evaluations of green-school improvements and related costs across the entire portfolio of school buildings. The team's assessment of the data (validated through MOES staff feedback) concluded that the Albanian portfolio of schools (3327 school buildings) built through 2011 could be represented by three conceptual models ("Types") of school buildings:

- **Type 1:** These are one-story freestanding buildings housing kindergartens in urban areas or, in more rural locations, kindergarten and/or 1-5 or 1-9 grade schools, and, in some instances, 10–12 gymnasium schools. The schools are constructed of plaster-over-brick masonry weight-bearing walls and have hipped wood-framed roofs with clay-tile roofing. The interior layout typically involves a central corridor with classrooms on both sides. Occasionally, the layout may involve classrooms opening onto a common courtyard.
- **Type 2:** These buildings are two-story free-standing, kindergarten, K–9, and 10–12 schools either with hipped wood-framed roofs or flat modern roofs. They are constructed either of plaster-over-brick masonry weight-bearing walls or are built with a concrete frame supporting plaster-over-brick walls, floors, and roofs. They have central corridors with classrooms on both sides and the overall building shape is either a long, linear block or either an "L" or "T" shape.
- **Type 3:** These buildings are three- to four-story freestanding grades 1–9 and grades 10–12 schools built with a concrete frame supporting plaster-over-brick masonry walls, floors, and roofs. They have a typical flat, modern roof with minimal or no overhang. They have central corridors with classrooms on both sides, and the overall building shape is either a long, linear block or an "L" or "T" shape.

Within these three types, MOES staff suggested additional variables that could be addressed in the construction specification and preconstruction cost-estimating process. The variables include a school having or not having access to roads, gyms, or yards. Several other variables relating to infrastructure were also identified by the ASU team to be important to the specification and costing process, including whether buildings are served by municipal water and sewer systems or by wells and septic systems. As data on these variables were not readily available for each school, several assumptions were made during the analysis phase of this study.

As the ASU research team moved from identifying building types to investigating the costs of construction improvements, it became clear that Type 2 and Type 3 buildings were very similar. The team decided that analyzing these building types separately would not provide useful insight and so consolidated them into Type 3. Thus the remainder of this report will focus on Type 1 and Type 3 building.

Typical building plans and elevations were prepared for both Type1 and Type 3 building “models” to assist in energy modeling, in construction specification, and cost estimating work for the upgrade strategies.



*Figure 23: Type 1 School in Existing Condition*



*Figure 24: Type 3 School in Existing Condition*

*Assumptions:*

With statistical data and input from MOES staff, the survey team decided that a school 929 square meters (10,000 square feet) or smaller in floor area would be treated as a Type 1 building. Any larger school would be treated as a Type 3 building. Although the Type 3 school buildings may have a variety of overall shapes (linear block, “L” shape, or “T” shape), they are constructed using the same basic building materials and units so estimating construction costs per square meter of floor space is reasonable. Energy models may vary somewhat based upon overall shape, but simplification was determined to be necessary and appropriate for the level of precision required for this project.

## Creating “Tiers” of Recommended Green Facilities Improvements

The nineteen Albanian school buildings visited provided a strong sense of general building conditions. The school infrastructure is in fairly good condition from an exterior or shell standpoint, other than water damage. Beyond the shell, almost all other systems need to be replaced or repaired to create minimally operational school buildings. While this statement may seem to indicate a daunting rehabilitation scenario, the quality and mass of the existing shells presents a **strategic opportunity** for inspired green building rehabilitation and transformation. Transformation of the solid, historic building stock into outstanding green and energy efficient buildings for education can position Albanian as a leader in sustainable green school and building infrastructure development.

### Tier Strategy for Rehabilitation Work

The integrity and value of the masonry building shells balanced against the somewhat daunting MPE and interior systems issues and an unknown level of retrofit funds indicated that a tiered strategy to building upgrades provided the most flexibility.

Specific upgrades were categorized into four conceptual tiers or bundles of work that could be performed all at once or sequentially to take the building stock from current conditions to a regional sustainability leadership position. Note that Tier 2 work should NOT be implemented before Tier 1 repairs because of the strong potential for inadvertently creating a much more severe mold situation. Note also that some costs would be saved by implementing several or all tiers at once on a given school, as re-work (such as replacing windows and lights twice) would be eliminated.

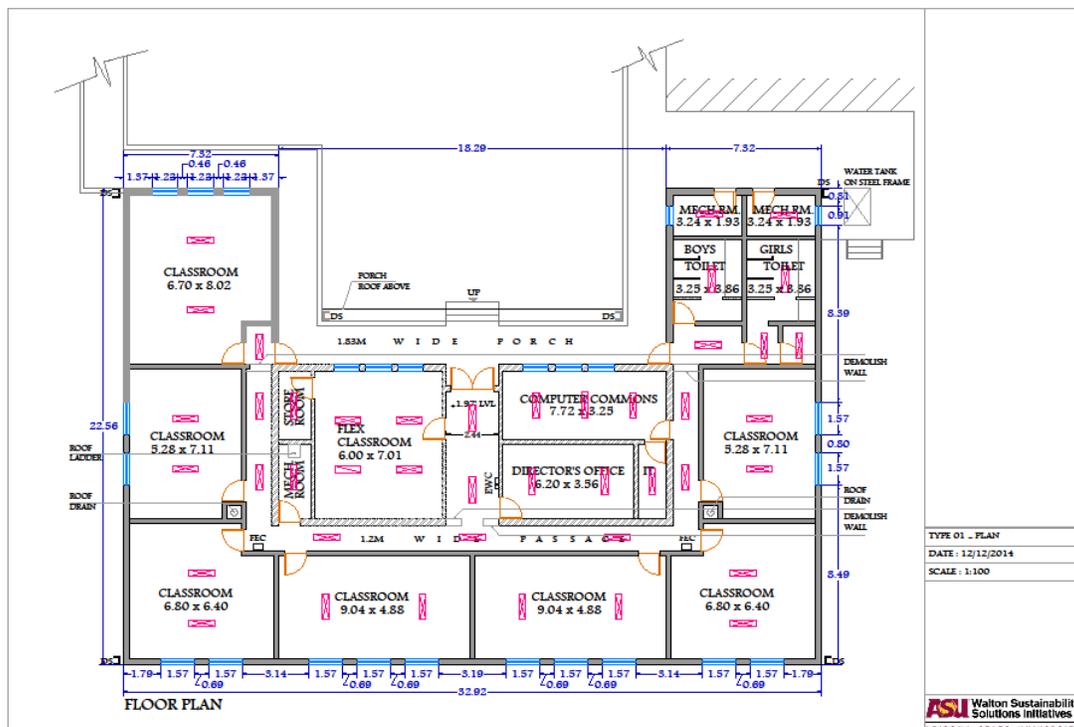


Figure 25: Floor Plan of Building Type 1 with Tier 1 Improvements

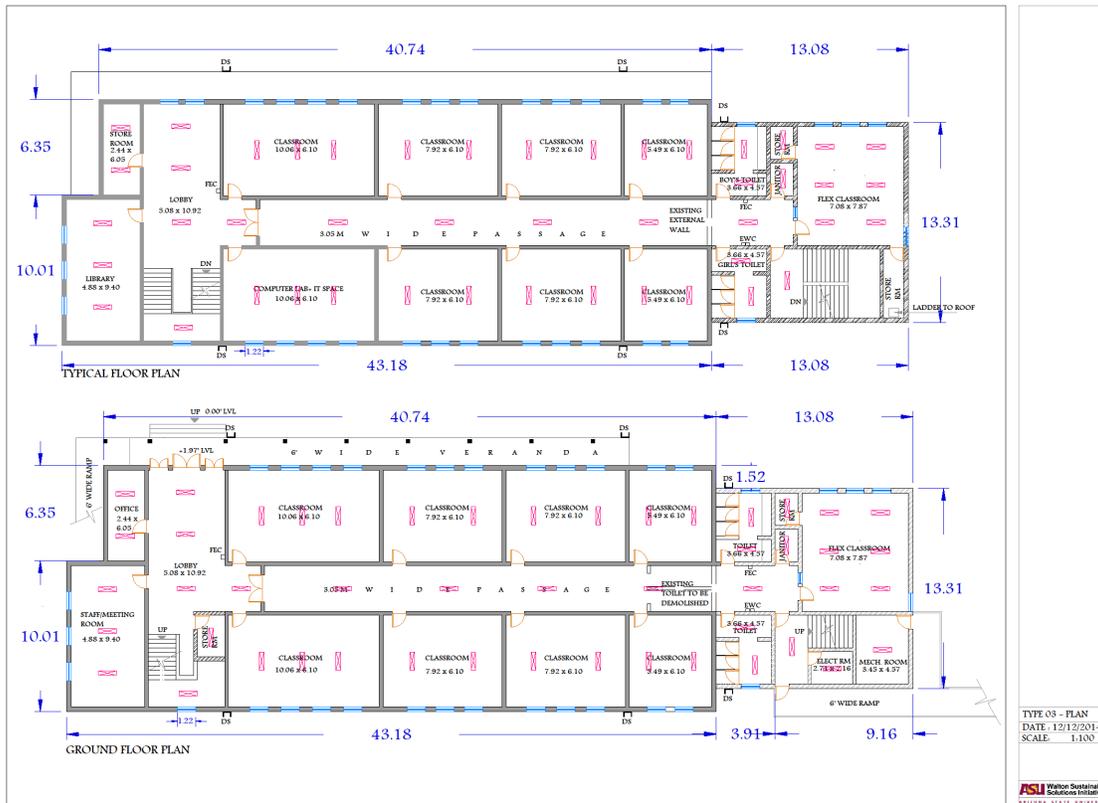


Figure 26: Floor Plan of Building Type 3 with Tier 1 Improvements

## The Conceptual Tiers of Work

**Tier 1 Goal:** Repair building shells and core operational systems and improve safety with adequate additional stairs for egress and emergencies.

- Repair building shells for water damage:
  1. Trench and repair foundations and repair roofs to eliminate water sources and dry out buildings.
  2. Remediate mold.
- Repair/replace windows with like kind (single pane, uncoated).
- Repair/replace interior doors.
- New electrical wiring system and repair fluorescent fixtures.
- New plumbing and waste system, toilets, and rooftop water storage.
- Remodel to provide fire egress and fire safety (smoke detectors and fire suppression system), and add stairs.
- New furniture, marker/chalkboards, and copiers.
- New low-voltage wiring for computer network systems.

**Tier 2 Goal:** Add passive energy efficiency and green elements (increase insulation, improve thermal control, and comfort).

- Add exterior rigid insulation and stucco finish to exterior walls.
- Add exterior rigid insulation to roof with new roofing system.
- Replace windows with quality, operable, dual-pane, low-emissivity windows.
  - Add argon gas to cold-climate windows.
- Add gravity-fed rainwater catchment to further divert water for use for landscape irrigation.
- Add exterior louver shade systems for window protection and reduced heat gain.
- Add interior window shades.
- Add wall mounted fans at classroom for cooling.

**Tier 3 Goal:** Add active renewable energy and green elements (improve comfort, generate power, and provide for possible future off-grid operation).

- Add radiant space heating.
- Add solar thermal system for hot water.
- Add solar photovoltaic system for a percentage of electricity generation appropriate to the amount of available mountable roof space.
- Replace lighting fixtures with LED fixtures.
- Add air conditioning at director's office and IT space (not included in energy model but negligible energy consumption).

The following additional improvement measures were considered as they are emerging in the market. They have little track record and are expensive because they are new but should be monitored for future viability and impact on sizing of solar photovoltaics.

- Add energy storage for continued equipment operation off-grid and/or during utility-outage.
- Convert power systems and fixtures/appliances to direct current (versus alternating current).

**Tier 4 Goal:** Add green education-enhancing improvements (that is, new educational space to meet Albanian educational space standards including gyms, outdoor sport facilities, learning gardens, teacher meeting and work spaces, and new flex classroom space). Add elevators to meet accessibility standards.

- Add new building areas:
  - Functional gym and outdoor sports facilities
  - Classroom and science lab space
  - Teacher/staff work space/lounge
  - Library/study space
  - Stairs, toilets, and storage space
- Add furniture, equipment, and ventilation systems needed to create lab spaces.
- Add interior acoustic materials for sound control.
- Design and add landscaping and school gardens as teaching tools.
- Add elevator for disabled access.
- Add wireless computer equipment resources, projectors and screens.

### Assumptions:

- Municipal service systems (electrical, water, sewer) are assumed to be operational in relationship to capacity and safety.
- Construction scope assumptions:
  - In Tier 4, all buildings will be priced for half the cost of new gymnasium space based on sharing of facilities among schools co-located on one campus.
- Infrastructure assumptions:
  - Mountainous: 100 percent of buildings with municipal connections
  - Hilly/Pre-mountainous climate zone: 50 percent of Type 1 buildings will require well and septic; 50 percent of Type 1 buildings and 100% of Type 3 buildings will already have municipal connections (water and sewer)
  - Field Mediterranean climate zone: 100 percent of buildings with municipal connections
- Climate zone assumptions:
  - All climate zones: add sunscreen louvers in Tier 2 and wall-mounted fans in classrooms in Tier 2
  - All climate zones: add solar PV for energy production; add space cooling for computer space in Tier 3
  - Hilly/Pre-Mountainous and Field Mediterranean climate zones: Add space cooling for director's office in Tier 3

### Determining Construction Requirements by Tier

Research for “pre-design” construction specifications was accomplished through review of MOES construction standards and specification information including model new school building plans and sets of construction document for other MOES recent projects. Standards adopted by the Ministry of Education in the December 2012 *Guidance for Designing the School Building, Norms and Standards, Volume 1* were used as a conceptual base, along with general standards from the International Building Code and sustainability standards, including the European BREAM and US Green Building Council's LEED rating systems.

The construction specifications were developed to describe the scope of work to be delivered in a phased manner by Tier, and organized according to construction categories of work generally understood internationally (using the US Master Specification format as the model). Two complete construction specification documents were developed, one for the Type 1 building and one for the Type 3 building. The specs include a general description of the building model “Type” and line item specifications for Tier 1 through 4 construction work with photos and site plan diagrams to illustrate construction improvement strategies. Building additions are shown in Tier 1 for code-required toilets, mechanical and egress space, and fire stairs. The building additions in Tier 1 are shown as logical design additions that will positively impact the architecture of the buildings while providing critically missing building areas. In both cases, some additional learning space is indicated to round out the architectural mass of the building additions and provide much needed learning space.

In the case of both building models, the existing buildings fall significantly short on providing the required amount of learning space per student, with Tier 1 work taking the first small steps towards meeting Albanian standards, and Tier 4 taking the final step to add significant learning space and outdoor learning environments that propel the buildings into the enhanced, educative

green building realm desired. Building additions and design concepts shown in Tier 4 include a complimentary new three-story addition connected by an interior breezeway link for building Type 3, and a new second floor addition for courtyard-type Building Type 1. Each building receives access to new athletics/gymnasium space (shared between schools located on the same campus) that frames outdoor space, an outdoor basketball court, courtyard space for outdoor learning activities and “learning gardens” that provide settings for interdisciplinary, project-based learning.

With each successive tier, the buildings will move towards transformation of the historic building stock into green, educative schools that will exemplify best practices in energy efficient school design and rehabilitation of existing building stock that highlights resource efficient design values. Moving from the existing buildings, the Tier 1 buildings become operational, safe and improved in appearance through exterior repairs, painting and addition of backup domestic water tanks that signal green design. Importantly, mold-causing rainwater is directed away from building foundations. With Tier 2 work, the buildings move into a higher level of comfort and aesthetic appeal through exterior insulation, stucco work and new roofing systems, and installation of new window and door systems. The buildings gain sunscreen louvers and visually interesting roof drainage downspouts that begin the visual transformation towards architecture that educates. In Tier 3 work, the addition of the photovoltaic systems on the building roofs heighten the building’s transformation towards energy efficient and energy producing facilities while heating systems provide for winter comfort. Tier 4 work moves each building towards the ultimate goal of twenty-first century, green school design with a focus on energy efficiency and resource efficiency through an impressive, macro-rehabilitation strategy.

#### *Assumptions:*

- Although many of the school buildings may require structural repairs (for example, repairs to the weight-bearing frame of the building), this work is not addressed in the specifications and cost estimating due to the need for detailed engineering analysis for each project.
- Scope of abatement for mold and asbestos is not inventoried; instead allowances are set for cost estimating purposes.
- Each building is assumed to require foundation drainage and waterproofing repairs, and grading work for “dewatering” of the structures.
- All buildings are assumed to need full bathroom replacement and replacement of electrical, plumbing, and sewer systems under Tier 1 work.
- All interior doors and frames are assumed to need replacement under Tier 1 work, and all windows and exterior doors are replaced with energy-efficient products under Tier 2. (Note: The window costs of Tier 1 can be eliminated in any decision to immediately upgrade to Tier 2.)
- All buildings are assumed to need new furniture and equipment systems.
- Each building type is indicated in Tier 4 with new athletic facilities, a gymnasium addition, and site development; each building is charged half the value of the new gyms, based on the assumption that buildings reside in institutional settings with other buildings that can share gymnasium space through proper scheduling.
- Based on cost and area constraints, elevators required for handicap access, universal design and building services needs are not added until Tier 4 when the major building additions are scheduled; up until Tier 4, buildings will not be in compliance with generally

accepted international accessibility standards. (MOES can decide to add elevators under Tier 1 work as an alternative strategy based on available funding.)

- See previous section for infrastructure assumptions for water and sewer supply systems.
- Each building is provided a backup tank for domestic water under Tier 1 work, based on the assumption that service from municipal systems is unreliable.
- All buildings are assumed to need backup generators to support levels of work for each tier; this cost is not included.
- Type 1 buildings are assumed to require renovation of historic clay-tile roofs with strategies documented that meet the Historic Building Treatment Standards of the US National Park Service (NPS Treatment Briefs).

### Determine Construction Cost Estimates

The building Type 1 and building Type 3 construction specifications prepared by the ASU team were reviewed and priced under the following four methods.

1. An in-house pre-design estimating effort following individual US specification divisions by the ASU team with assistance from the Del E. Webb School of Construction and with supplementary estimating information gained from a local Phoenix architectural firm and multiple local Phoenix construction firms specializing in schools
2. Partial pre-design pricing by a reputable Albanian contractor.
3. Pre-design pricing by a reputable Albanian architectural firm specializing in government buildings.
4. Pre-design pricing by an Albanian contractor with strong experience in local school construction.

With comparison of the four different sources of cost information, it was determined that information from sources 1, 2, and 3 could be compared and integrated to provide one complete source of cost information called **Model A**, with source 4 left as **Model B**. Hence, the preliminary pre-design cost estimates were generated from comparison of values between Models A and B to derive final cost-per-square-meter estimates that could then be scaled across the entire portfolio of schools. Assumptions and clarifications include the following:

#### *Exclusions from Cost Estimates:*

- Any potential escalation of construction costs due to phased implementation
- Remoteness costs
- Design contingency
- Structural repairs
- Backup generator systems, which will be required for Tier 1 work and then enlarged for Tier 4 additions

All construction costs are conceptual and ASU recommends conducting pilot projects that go through the entire standard design and procurement processes to validate costs on each building type in each climate zone in both rural and urban settings.

#### *Assumptions and Clarifications:*

- Rates are Albanian with a rate adjustment for upgrading beyond the Albanian government-approved pricing schedule to ensure quality construction for green school

design. The ASU team received conflicting information from Albanian contractors as to whether the government pricing schedule was low and encouraged substandard quality in materials and workmanship or was, in fact, higher than market rates.

- Assumed primary sourcing of construction materials and systems from Albania, with sourcing of high technology and PV solar systems from Italy or another nearby EU country. The following information was gleaned from an Internet search and interviews regarding potential domestic materials sourcing:
  - Cement: Fushe Kruja
  - Iron Construction: Elbasan
  - Bricks: Tirana
  - Stone, Travertine: Muhuri
  - Wood products and furniture: Durres
  - Windows: Tirana
- The assumption of half athletic/gymnasium space being charged to each building creates somewhat of an economic hardship on the smaller Type 1 schools that constitute the majority of schools within the Albanian portfolio. For conceptual analysis purposes, however, the ASU team determined that indoor space for movement and athletics is a critical feature of twenty-first century “green and educative” schools and should therefore be included.
- Cost markups are based on US standard practices (bonds, insurance, contractor profit, fees, etc.).

**Model A: Methods and Assumption Details:** This hybrid model compared US construction cost estimates to new construction cost estimates provided by an Albanian architect using the Albanian government pricing schedule applied to a comparable scope of work. The comparison resulted in a US-to-Albania adjustment factor of 32.8 percent. In other words, Albanian costs are assumed to be approximately 32.8 percent of equivalent work US construction costs.

- US costs are based on applying “RS Means” (a private sector data source for construction costs)<sup>i</sup> cost data to “pre-design” work effort estimates. RS Means data were augmented by cost estimates from Arizona contractors (unit costs for new school construction; furniture, fixtures, and equipment (FF&E); site development work and specific mechanical systems (such as boilers and fuel tanks).
- US costs include 14.5 percent markups (contractor profit, fees, bonds, insurance) and Albanian costs include all markups, which are assumed to be commensurate with US markups.
- It was assumed that Albanian costs for new construction for Tier 4 include FF&A and site development work costs, similar to US costing methods.
- For items such as solar PV, which are not currently available in Albania, Italian pricing was utilized for Tier 3 estimates.
- For Tier 2, windows priced in Model A are better and more energy-efficient than those priced in Model B.
- In Tier 3, an allowance was added for an adequately sized boiler backup fuel tank and safety features to meet US safety standards.

**Model B: Methods and Assumption Details:** This model centers on total cost per square meter of school space pricing by a reputable Albanian contractor using ASU-provided construction specifications.

- FF&A costs are included.
- Site development work costs do not appear to be included, but water and sewer supply systems appear to be included.
- Tier 2 pricing does not include sunscreen louvers, which is different from Model A.
- ASU made adjustments to Tier 2 pricing to account for structural needs on building Type 1 historic clay tile system.
- Tier 3 pricing for solar PV systems did not appear to be included, so it was added.
- Adjustments were made to Tier 3 pricing to accommodate US safety standards and backup fuel tank for the boiler heating system.

### Modeling Energy and Comfort Impacts

A variety of tools were used to model classroom comfort conditions and building energy use of both building types across Tiers 1–3 in the three climate zones. Those tools included AutoCAD 2015, eQuest, Climate Consultant, Autodesk EcoTect, and PV Watts. Comfort was analyzed using the American Society of Heating, Refrigeration, and Air Conditioning Engineers' ASHRAE 55, an Adaptive Comfort Standard, accounting for occupants' tendency to use clothing and other strategies to adapt to a range of temperature and humidity conditions, particularly in buildings where windows are often used to control climate, and to acknowledge Albanians' broader interpretation of comfort than European and US populations. Comfort was modeled for each building type in both north/south orientation and east/west orientation.

#### *Assumptions:*

- Teachers open the windows when outdoor air conditions are able to provide better comfort than indoor conditions with windows closed.
- As Tier 1 does not include electric fans to draw outdoor air into the building, natural ventilation during times when windows are open will be inadequate to flush out the hotter indoor air. Consequently a simplification was made that the indoor comfort percentage at those times will be equal to the average of outdoor comfort and indoor comfort levels.
- For Tier 2, when the windows are open the indoor comfort percentage is assumed to be equal to the outdoor comfort since electric fans will adequately ventilate the indoor spaces.

For an in-depth review of the comfort and energy methodology, assumptions, analysis and results, see Appendix A: Evaluating Different Green School Building Designs for Albania: Indoor Thermal Comfort, Energy Use Analysis with Solar Systems.

### Determining Climate Zone Locations of Schools

Energy-efficiency strategies are typically very climate-specific. In order to determine the appropriate improvements for a given school and to model the potential energy savings, the ASU team sought to understand the climate zone of the location of each school. The only known climate zone map was produced by the Institute of Hydrometeorology (IHM) of Albania in 1978, which identifies four climate zones in Albania: Field Mediterranean (low, coastal climate);

Hilly Mediterranean; Pre-Mountainous Mediterranean; and Mountainous Mediterranean (IHM 1978). For simulation purposes, Hilly Mediterranean and Pre-Mountainous Mediterranean were combined.

The MOES provided GPS coordinates of each school, developed as a result of the EU-funded Support Albania's Ministry of Education and Science to Develop a Management Framework for Investments in Pre-University Education Facilities project (TA-ALB-10). However, the ASU team was unable to reconcile the coordinates to the underlying coordinates system provided. As an alternative method, the ASU team used an application program interface to Google Maps to identify the GPS coordinates of the village in which the school was located. For the 487 of 3,327 schools where Google Maps did not recognize the village name, the administrative unit was used. In a few cases where the administrative unit was not recognized, the broader district was used.

The low-resolution JPEG climate zone map from IHM was overlaid with the village GPS coordinates in the GIS software and hand-modified to conform to the GIS map of Albania. Any school located on a climate zone boundary was manually assigned to the nearest climate zone. The data was then exported to a spreadsheet to link each school, number of floors, and total floor area with the appropriate climate zone. These data were then aggregated to determine the total floor area by school type by climate zone.

#### *Assumptions:*

- The climate zone for 1.75 percent of schools could not be determined based on data and process constraints. Therefore, floor space for these schools was attributed proportionately to the other three climate zones.

#### **Applying Construction Costs and Energy Impacts across the Portfolio of Schools**

Once costs per square meter for each tier of improvement were set for both building types, those costs were scaled according to the total square meters of floor space across the country for each building type in each climate zone. It was unexpected and noteworthy that Type 1 schools constitute nearly 95 percent of Albanian schools.

#### *Assumptions:*

- It is assumed that all Type 3 buildings have municipal water and sewer connections because they are expected to be located in metropolitan areas.
- It is assumed that 50 percent of Type 1 buildings in the Hilly Mediterranean/Pre-Mountainous climate zone have water wells and septic tanks versus municipal system connections because many of them are located in rural areas. Costs were adjusted accordingly. 100 percent of Mountainous climate zone Type 1 and 3 schools were priced as having municipal connections.
- Climate zone does not significantly impact construction costs as energy modeling suggests that heating, sunscreens, and classroom fans are important in all climate zones whereas cooling is not necessary.
- All cost scaling is based on existing square meters of space, including the costs of adding substantial new space to meet Albanian space standards under Tier 4 work
- Type 1 building costs were applied to all buildings that are 929 square meters or smaller.

- Type 3 building costs were applied to all buildings that are greater than 929 square meters.

## Modeling Economic Impacts due to Construction Investment and Energy Savings

Economic impact analysis traces the full impact—direct, indirect, and induced—of an economic activity on jobs and incomes in a local economy. Operations such as upgrading Albanian schools directly affect the economy through the jobs provided to workers hired to perform the upgrades (such as installing well and septic systems, insulating the buildings, and installing solar photovoltaic rooftop systems). Indirect effects include jobs supported among suppliers and also arise when these suppliers place upstream demands on other producers. Induced effects occur when workers either directly or indirectly associated with the school improvement construction work spend a portion of their incomes in the local economy. The sales, income and jobs that result from household spending are all induced effects.

In the end, the cumulative changes in jobs and incomes are a multiple of the initial direct effects—hence the term “multiplier effects.”

Economic impacts were estimated using an input-output model developed by the Seidman Institute, based on GTAP (Global Trade Analysis Project) data for Albania (Narayanan 2012). An input-output model is a system of linear equations which describes the inter-industry relationships in an economy. In addition to providing estimates of multiplier effects, an input-output model has a detailed database which makes it possible to estimate the direct jobs and incomes associated with any given dollar amount of expenditures (sales) in a specific industry. The economic model developed for this project can be used to evaluate other potential investment projects in Albania.

Economic impacts were measured in terms of four variables:

- GDP is synonymous with value-added. It represents the monetary value of all goods and services produced for final demand in the country. It excludes the value of intermediate goods and services purchased as inputs to final production.
- Employment is a count of full- and part-time jobs. It includes both wage and salary workers and the self-employed.
- Labor income includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income.
- Output comprises the value of industry production, or the value of all goods and services produced in the region. Output double-counts the value of production from an economy-wide perspective and is considered a less meaningful measure of economic impacts when compared to value-added.

The economic impacts of school upgrades on Albania are significant but it must be kept in mind that they will last for a relatively short period of time.

### *Assumptions:*

- The upgrades will most likely be funded with foreign capital. Hence no trade-offs within Albania—money that could alternatively fund other Albanian projects or the taxpayers would have to support—are taken into account. All benefits accruing from the project will be net benefits to Albania.

- Monetary amounts are reported in current US dollars.
- For the sake of clarity, we assume that the upgrade work will take place during one year; so jobs and other economic impacts will occur during one year. If work takes place over a longer time period, the economic effects can simply be spread across that timeframe, as they are related to the size of investment/construction expenditure, which will be the same regardless of duration.
- The input-output model does not capture economic impacts of training. For example, workers in Albania are not familiar with installing solar PV panels and need to be trained. There may be positive effects in terms of future labor market outcomes for these workers, as they will have acquired better skills.
- The input-output model allows for migration. Primarily workers are assumed to be available locally, but the number of jobs that are created in certain scenarios—especially for Tier 4 upgrades—are high, so the local labor supply may not be large enough to satisfy demand. In such cases, workers could migrate from other countries to Albania.
- For simplicity, salaries and wages are assumed to remain constant at current levels for the duration of the project.

### Calculating Carbon Emissions Based on Portfolio Energy Impacts

As the impacts of human-caused climate change become more pronounced and global efforts become more urgent, Albania has a particular interest in combatting this global phenomena. Recent flooding and fire events have illustrated the potential consequences of climate instability for Albanians. To its advantage, Albania already generates a large amount of hydropower, a clean, renewable power source. However, hydropower would be negatively impacted should climate change reduce rainfall in the region, as expected.

Electricity consumption is often one of the largest sources of emissions when reporting organizations and companies complete a greenhouse gas inventory (Brander et al. 2011). The amount of emissions produced is based on the power mix of how the electricity is generated. It is fortunate for Albania that over 90% of their electricity is produced by hydropower plants and that most energy is consumed as electricity. This results in CO<sub>2</sub> emissions in Albania that are 4 to 5 times lower than the average industrialized country (Islami et al. 2009).

Albanians emitted  $1.00988 \times 10^{-5}$  metric tons of CO<sub>2</sub> for every kilowatt-hour of electricity used in 2011 (Brander et al. 2011). This emissions rate was calculated by applying the appropriate default emission factors for various electricity production sources from the Guidelines for National Greenhouse Gas Inventories (IPCC 2006) to Albania's electricity generation source mix. The CO<sub>2</sub> emissions impacts that result from the changes in energy consumption of the schools due to green improvements are estimated in Figure 26 (as with energy impacts, Tier 4 CO<sub>2</sub> impacts are not estimated).

#### *Assumptions:*

With the wide distribution of schools across the geographic territory of Albania, it is assumed that any regional variations in energy sources are canceled out through the portfolio effect.

## Recommendations for Next Steps

The Ministry of Education and Sports' implementation strategy for this project will be shaped by the capacity and willingness of international funders and Albanian taxpayers to invest in Albanian students' education and the economy. A few considerations:

- Generally, addressing the tiers of improvements sequentially and specifically ensuring that Tier 1 is addressed before Tier 2 in order to prevent more severe humidity and mold issues is critically important.
- Conducting pilot projects on different types of schools in three climate zones (and in urban and rural settings) with intensive monitoring to refine the scaling of cost estimates, educate contractors and the school community, build material supply chains, verify analyses, and illuminate unknown opportunities and challenges is suggested as the next step.
- Pilot projects that involve detailed design, construction drawings, cost estimating, quality assurance, and monitoring procedures throughout the process are critical to:
  - a. Validate improvement strategies at the building level by climate zone, by building Type, by setting, and by remoteness. Among other issues, it is critical to validate whether the moisture-related strategies of Tier 1 are sufficient to prevent mold growth in the schools or if the lack of a moisture barrier under the slabs compromises the effectiveness of the dewatering strategies.
  - b. Refine cost and savings estimates.
  - c. Train construction industry professionals and teachers/directors.
  - d. Build public and donor support for scaling to all schools and/or tiers.
  - e. Study learning benefits.
  - f. Scientifically collected data—such as before and after attendance records, energy data, thermal comfort and indoor environmental quality data, health data, assessment scores, and more—would allow the Ministry to make more informed decisions, and could also be used in generating cutting-edge, internationally impactful green schools research that solidifies Albania's leadership in this area.

In alignment with our evidence-based research, ASU recommends the Ministry of Education and Sports pursue the strategies and actions outlined below.

- **Implement a pilot program of improvements in 36 school buildings.**
  - 3 buildings x 2 building types (i.e., XYZ) x 3 climate zones (field, hilly & pre-mountainous, and mountainous) x 2 settings (rural and urban) = 36 school buildings
  - Set a minimum target of Tier 2 improvements for the pilot schools with a goal of implementing through Tier 4 improvements on at least twelve of the schools—one representing each type, climate zone, and setting combination.
  - Select pilot schools to be geographically dispersed throughout the country to benefit a wide range of citizens and better understand the impacts of remoteness on costs and procedures. These pilot projects can serve as demonstration projects to train contractors, architects, inspectors, students, teachers, and directors.
- **Initiate (in partnership with the Ministry of Health, Social Welfare and Youth) the phased development of a domestic solar photovoltaic (PV) industry that would**

**utilize vocational and adult education schools for training and the Ministry of Education and Sports' schools as the "first customers."**

- **Require all new schools be built to Tier 4–equivalent standards and used as demonstration projects for contractor training and stakeholder awareness.** The newly completed Hyseh Cela Durres vocational school appears to provide an example for demonstrating domestic construction expertise to attain the goal of a green and energy efficient school system future.
- **Evaluate and choose a scaling plan based on funding availability and lessons learned in the pilot phase.** If funding availability suggests a phased approach to scaling, ASU recommends an evaluation of the following scaling strategy options:
  - Bringing all schools up to an achievable tier, keeping in mind that Tier 2 appears to provide a high cost-to-value ratio;
  - Improving the schools that are most in need to the highest tier possible; and
  - Implementing selective measures from various tiers while being conscious of safety and re-work cost issues related to the sequencing described later in this document.

## Conclusion

Albania has a chance to become not only a regional but a global leader in green school implementation, particularly in existing school retrofits. Existing schools employ design techniques that are inherently beneficial to green schools, but major improvement work involving significant investment is needed both to make the schools sustainable and to bring them up to European Union educational standards. If implemented properly, the amount of energy consumed by schools will be significantly less than otherwise needed to provide education facilities that meet Albanian government minimum per student space standards and educational facility operational standards. Learning enthusiasm among students, teachers and directors is also high. Ministry-initiated changes that incorporate sustainability into the curriculum are already underway and can be enhanced and supported through transformation of Albania's school infrastructure into model, green built facilities.

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## Appendices

Appendix A. Energy and Comfort Simulations

Appendix B. School “Type” Plans

Appendix C. Construction Specifications: Type 1 Schools

Appendix D. Construction Specifications: Type 3 Schools

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