GROW LIGHTS

Sustaining the World
Next Generation Produce and Flowering Plants, plus Algae for Biofuel

www.IndependenceLED.com
As global population rises and life expectancy increases, the world has a growing appetite for:

FOOD     WATER     FUEL

Energy-efficient LED grow light technology can serve as a key part of an integrated solution.
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Overview: Sustainability CHALLENGE

**Sustainability CHALLENGE:**
Global demand may exceed the supply of food, fuel, and water.

**FOOD:** Severe droughts and floods put certain sectors at risk. Pesticides need to work harder to offset crop damage. Bioengineered seeds reduce the range of sub-sets and increases blight risk. Organic food comes in from outside of the markets where it is consumed. Inner city residents often have less access to fresh produce than other markets. U.S. childhood and adult obesity is rising at alarming levels due to sugar intake and processed foods over fresh produce.

**WATER:** Traditional food production requires significantly more water than the public realizes. It takes just 6 gallons of water, with traditional farming to produce a head of lettuce, but it takes over 1,000 gallons to produce a cheeseburger with lettuce, because the feed for the cows is so inefficient to grow as well as the water used to sustain and clean the cows over their life prior to processing. In the U.S., we have drained a significant portion of the mid-west aquifers, which were filled over millions of years.

**FUEL:** Long haul transportation for truck ripened and also organic produce is one of many growing demands on fuel. Global population increases bring rising demand for everything from hand held electronics to home heating and cooling.
Overview: Sustainability STRATEGY

Sustainability STRATEGY:
Focus on localized hydroponic food production. By growing indoors, pesticides are not required, and drought and flood risks are reduced. Plus, hydroponics use less water than traditional farming. Local indoor “micro-farms” will reduce transportation fuel consumption. Imagine grow centers in buildings near or even inside of inner city schools, to help feed a new generation organic food that is the cornerstone of healthy living.

Lighting Challenge:
The cost of electricity for grow lights has slowed the adoption of indoor hydroponics to date.

LED Solution:
Light Emitting Diode (LED) technology has the ability to reduce the cost of illumination by 25% or more. To date, the LED hurdle has been growing as much produce over the same period of time as traditional incandescent, metal halide, fluorescent, and induction lights.

Independence LED Results:
This report includes recent results from ongoing development work. Over the past year, through our R&D, Photosynthetically Active Radiation (PAR) Meter, and Third Party Consultants and Testing, we have identified the light wavelengths to reduce energy consumption AND increase plant growth.
Overview: High Level LED IMPACT

High Level LED IMPACT:

Sample Early Growth Testing Results:

Independence LED yields:

25% REDUCTION in electricity consumption

AND

25% INCREASE in initial plant growth
Growth Testing: PROTOCOL
In order to provide ongoing and meaningful testing, Independence LED works with outside companies dedicated to accurate measurement and verification for parallel testing consistency. Please note that Independence LED has learned from earlier prototype luminaires that it has developed across the R&D process to maximize the efficacy at each level.

The testing protocol includes:
• Third Party Indoor Growers
• One testing variable: Lighting

Consistent treatment of:
• Source Plants
• Water
• Nutrients
• Temperature
• Illumination and shut down time

For the testing documented on the following pages, Basil was grown with 16 hours of illumination followed by 8 hours of rest per day. (Please note that Independence LED will also explore sunrise and sunset effects since the LEDs are dimmable. Plus, R&D will include split shifts of 8 to 10 hours with 4 hours of rest, simulating two days of growth inside of one calendar day.)
Vertical Grow System (VGS)

LEDs run cooler than fluorescent/induction. So, chains can suspend the LED fixtures closer to the plants. The fixtures are periodically raised up as the plants grow.

Non-LED technology can burn young leaves given the heat impact of the lights and the way that the fixtures trap hot air.

The Independence LED fixture is designed with multiple linear modules that allow the air to circulate up and away from the plants.
Testing Baseline: Independence LED challenged the best of traditional lighting. Induction is an advanced form of fluorescent, and Inda-Gro (www.inda-gro.com) is a leading grow light manufacturer. Inda-Grow marketing, “Induction Grow Lights provide your plants the best horticultural lighting for explosive growth and high yields from a single lamp source that is used for the entire vegetative through flowering cycle while saving between 60-70% of the energy consumed by traditional lamp technologies.”

LED: 307 Watts Per Fixture
(Optimized Wavelength Light)

Induction: 420 Watts Per Fixture
(White Light)

113 W Saved
26.9% Savings
Growth Testing: LED vs Induction

Plant: Basil
Study Sector: Leafy Green Vegetables

Growth Days: 3

These photos were taken 3 days after the plants were moved from the seedling nursery to the VGS. They were in the nursery for 10 days prior to the VGS.
The baby plants are comparable in plant height at this early stage. These photos were taken 3 days after the plants were moved from the seedling nursery to the VGS. They were in the nursery for 10 days prior to the VGS.
Testing Analysis: Leaves
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 15

Growth Days: 15

Induction

LED

More Robust Leaves with LED
Testing Analysis: Leaves and Roots

Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 15

Growth Days: 15

Induction  LED

More Robust Leaves and Roots with LED
Analysis: Weight
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 15

Growth Days: 15

Induction

LED

.7 oz. = 19.83 gram

.9 oz. = 25.50 gram

Additional 5.67 grams = 28.59% greater weight
(Note this includes the added roots at this stage)

Conversions: 1 ounce (oz.) = 28.34 grams. 1 pound (lb.) = 16 oz. and 453.59 grams

www.IndependenceLED.com
Testing Analysis: Infant Leaf Count

Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 15

Growth Days: 15

Induction

LED

1
(3 total)

3
(5 total)

2 Additional = 66% more lower infant leaves
(Note this is key for multiple harvests. See “Harvest Sequence”)
Testing Analysis: Root Length
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 15

Growth Days: 15

Additional 2.75” = 31.4% greater root length
Testing Analysis: Plant Profile

Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 15

Growth Days: 15

Larger Plant Profile with LED
Testing Analysis: Organic Surface Area
Plant: Basil  
Study Sector: Leafy Green Vegetables  
Growth Days at Testing: 15

Note: Surface Area analysis is conducted by flattening out the leaves and aligning them vertically relative to the levels of plant growth. From the bottom up, the LED resulted in significantly more roots, two “new born” vs zero, 5 infant leaves vs 3, comparable primary leaves, larger upper level leaves, and 2 vs 1 top upper growth leaves.
Testing Analysis: Longevity
Plant: Basil
Study Sector: Leafy Green Vegetables

15 Days of Refrigeration

Induction

LED

This is the outcome after 15 days of refrigeration of the organic material under the same conditions of a residential refrigerator. The LED leaves retained a significantly higher level of color, texture and flavor vs the Induction leaves that browned and wilted.
Testing Analysis: Mounting Height

Plant: Basil
Study Sector: Leafy Green Vegetables

Growth Days: 1 to 15

First 15 Days
Mounting Height
8” from Baseline

Nutrient Enhanced Hydroponic Growth Platform
Testing Analysis: Organic Surface Area
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

2 Weeks
(15 Days Later)

30 DAY PROGRESS – First HARVEST
Note that the following pages reflect the results from the first of 7 harvests that occur every 15 days before the plant is retired.

Within this first 15 day “Harvest Period”, the mounting height of the LEDs was raised by 4” one a week.

Subsequent tests include raising the lights by 1.5” every three days to more closely track the growth of the plants in an effort to deliver even more yield. All plants are vulnerable to burn out if lights of any kind are too close to leaves. This optimized growth testing initiative involves finding the right distance above the plants and the right timing to make the mounting height adjustment.
Testing Analysis: Leaf Weight

Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

Induction = LED

See the Optimization section of this Report for tactics to lift the LED production above Induction while maintaining the 25% energy savings. The brownish “wilting” is a function of the 4 hour transportation longevity aspect of this testing process.

Conversions: 1 ounce (oz.) = 28.34 grams. 1 pound (lb.) = 16 oz. and 453.59 grams
Testing Analysis: Leaf and Stem Weight

Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Leaf and Stem Weight

This weigh-in occurred after both plants were in the same vehicle for 4 hours to simulate transportation extreme conditions on an 80 degree day in late May. Given that the developing world does not have the same level of climate controlled vehicles as the U.S.A. and other countries, this longevity testing is key in the lifecycle of farm to table solutions.

Conversions: 1 ounce (oz.) = 28.34 grams. 1 pound (lb.) = 16 oz. and 453.59 grams
Testing Analysis: Stem Weight

Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

Induction

LED

.6 oz. = 17.00 grams

.3 oz. = 8.50 grams

Reduction of 8.5 grams = 50% shipping weight savings

With optimized Mounting Height testing this delta may change with larger vertical growth for the LEDs.

Conversions: 1 ounce (oz.) = 28.34 grams. 1 pound (lb.) = 16 oz. and 453.59 grams
Testing Analysis: Stem Height
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

Reduction of 2” = 21% more Vertical Grow Shelves
The more compact LED stem yielding the same leaf weight creates an opportunity to farm 20% more plants in the same area through vertical grow stand techniques. With optimized Mounting Height testing this delta may change with larger vertical growth for the LEDs.
Testing Analysis: Vertical Area

Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

Over 20% Vertical Area Savings
Testing Analysis: Vertical Area
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

Sample 4 Rack Vertical Grow System for Induction Lighting
Testing Analysis: Vertical Area
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

Induction: 4 Racks
LED: 5 Racks

20% More Growth per Sq. Ft. with LEDs. 5 LED Grow Racks vs 4 Induction

This is the beginning of R&D into “dwarf” plant strategy to maximize real estate.

www.IndependenceLED.com
Testing Analysis: Farm Review
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

Induction
4 Racks

LED
5 Racks

Induction will burn plants if the bulbs are brought closer than 20” to the leaves. LEDs run cooler than other lighting and the Independence LED advanced heat sinks and modular linear system allows hot air to pass up through the fixture.
Testing Analysis: Organic Surface Area
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

Induction

LED

Upon visual inspection, the leaf matter appears to be larger with the Induction lights than with the LEDs. However, both plants yielded the same total weight and the following page illustrates that the LED leaves are denser and in some cases equal the weight of two Induction leaves. The brownish wilting is due to the 4 hour transportation longevity testing aspect of this initiative.

Weight Cross Check:
Leaves harvested from 83 Induction gown plant = 3lb 341 grams (1,701.77 grams)
Leaves harvested from 83 LED gown plant = 3lb 235 grams (1,595.77 grams)
Delta of 106 grams or 6.2% difference. The optimized LED Mounting Height is expected to shift this in favor of the LEDs.

Conversions: 1 ounce (oz.) = 28.34 grams. 1 pound (lb.) = 16 oz. and 453.59 grams
Testing Analysis: Leaf Weight Comparison
Plant: Basil
Study Sector: Leafy Green Vegetables
Growth Days at Testing: 30

Growth Days: 30

The LED leaves are denser and in some cases equal the weight of two Induction leaves. The brownish wilting is due to the 4 hour transportation longevity testing aspect of this initiative. The more robust LED leaves did not suffer as much travel fatigue as the Induction leaves.
Texture:
The large LED “canopy” leaves feel heartier, thicker, and firmer to the touch than the more softer and supple Induction leaves. The transportation stress test and the refrigeration longevity test bear out the robust aspect of the leaves relative to the softer and lighter induction leaves. This may be a key differentiator for food cultivation in the developing world. The strain of Basil tested is for pesto sauce and organic mass is naturally a key aspect of pesto production. The mid-size and smaller leaves under the canopy have a softer feel that is closer to the texture of the Induction leaves. Further LED growth testing with the adjusted mounting height that tracks up with plant growth will help determine if the heavier leaves are a function of the LED proximity to the leaves or the LED wavelength mix and output levels. Plus, the ripples and few areas of cracking on the top LED leaves are most likely a function of too much LED light too close to the leaves.

Aroma:
The softer more supple Induction leaves give off a more pungent “basil” aroma than the large LED canopy leaves. However, the mid and small size LED leaves mirror the aroma of the Induction leaves.

Taste:
The Induction leaves have a more “basil” taste than the large LED canopy leaves. Chewing the leaves on different sides of the mouth reveals that the Induction basil is more tender while the LED basil is more firm and crisp. However, the mid and small size LED leaves mirror the taste of the Induction leaves.

Comprehensive Analysis:
R&D Funding will help provide more data sets across different phases of growth.
Nutrients:

Nutrient analysis typically comes via “Tissue Testing.”

Laboratory testing will identify the mix of nutrients in the LED grown plants relative to Induction plants.
Optimization:

• Harvest Cycles
• Mounting Height
• Wavelength Mix
• Reflectors
• Fixture Configuration
Testing Analysis: Harvest Cycles

<table>
<thead>
<tr>
<th>Seedling (10 Days)</th>
<th>Toddler (15 Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>e.g. First 15 Days under LEDs</td>
</tr>
<tr>
<td></td>
<td>Child to Adult (15 Days) ending in “H” Harvest</td>
</tr>
<tr>
<td></td>
<td>e.g. Second 15 Days under LEDs</td>
</tr>
</tbody>
</table>

7 Harvest Cycles
Every two weeks for 2 ½ months before retirement
(At each harvest the large and mid size leaves are removed)

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seedling (10 Days)</td>
</tr>
<tr>
<td>2</td>
<td>Toddler (15 Days)</td>
</tr>
<tr>
<td>3</td>
<td>Child to Adult (15 Days) ending in “H” Harvest</td>
</tr>
<tr>
<td>4</td>
<td>Retire</td>
</tr>
<tr>
<td>5</td>
<td>Seedling (10 Days)</td>
</tr>
<tr>
<td>6</td>
<td>Toddler (15 Days)</td>
</tr>
<tr>
<td>7</td>
<td>Child to Adult (15 Days) ending in “H” Harvest</td>
</tr>
</tbody>
</table>

Plant: Basil
Study Sector: Leafy Green Vegetables
Both the Induction and the LED fixtures yield taller plants directly under the fixture than on the outside edges, resulting in a growth “hump”. The LEDs outpaced the Induction over the first 15 days when the fixture (dashed line) was 8” above the baseline. Over the second 15 days, the fixture was moved up 4” but it may have been too close and prevented potential growth. Subsequent testing will include 1.5” lift twice weekly (4 lifts) to maintain 8” of distance between the top of the plant and the LEDs. The may net to an 18” distance from baseline to fixture with an expected 9” to 10” plant at harvest time.
Testing Analysis: Mounting Heights
Plant: Basil
Study Sector: Leafy Green Vegetables

RESULTS
After optimizing the slight increase in space between the LED fixtures and the plants. (1.5” lift twice a week)
Testing Analysis: Leaf Weight
Plant: Basil
Study Sector: Leafy Green Vegetables

Growth Days: 45 (2nd 15 Day Harvest Cycle)

**LEAF WEIGHT:** The optimized LED system yields over twice as much food with 25% less energy cost.

Reference - 1st Harvest Cycle  Pre Optimization:
.8 oz. = 22.6 grams

Conversions: 1 ounce (oz.) = 28.34 grams.  1 pound (lb.) = 16 oz. and 453.59 grams

Induction

.6 oz. = 17.04 grams

LED

1.3 oz. = 36.84 grams
Testing Analysis: Leaf and Stem Weight  
Plant: Basil  
Study Sector: Leafy Green Vegetables

Growth Days: 45 (2\textsuperscript{nd} 15 Day Harvest Cycle)

Leaf and Stem Weight

The total LED plant weight is 26.6\% higher than the Induction plant weight. For reference the pre-optimized harvest cycle came in with the Induction at 1.4 oz and the LED at 1.1 oz. While the Induction basically maintained its weight yield, the LED plant grew significantly larger within the second harvest cycle given the optimized distance between the plants and the LED fixtures.

Conversions: 1 ounce (oz.) = 28.34 grams. 1 pound (lb.) = 16 oz. and 453.59 grams
Testing Analysis: Stem Weight
Plant: Basil
Study Sector: Leafy Green Vegetables

Growth Days: 45 (2nd 15 Day Harvest Cycle)

STALK WEIGHT: The optimized LED doubled its stalk weight while the Induction only increased by 50%.

Reference - 1st Harvest Cycle Pre Optimization:
.6 oz. = 17.00 grams
.3 oz. = 8.50 grams

Conversions: 1 ounce (oz.) = 28.34 grams. 1 pound (lb.) = 16 oz. and 453.59 grams
Testing Analysis: Stem Height
Plant: Basil
Study Sector: Leafy Green Vegetables

Growth Days: 45 (2\textsuperscript{nd} 15 Day Harvest Cycle)

While the Induction plant stalks are similar in proportion between the 1\textsuperscript{st} and 2\textsuperscript{nd} harvest cycle, the LED plant grows dramatically wider and more robust, especially with the lower level stalk branches as well as the upper level branches.
Testing Analysis: Organic Surface Area
Plant: Basil
Study Sector: Leafy Green Vegetables

Growth Days: 45 (2nd 15 Day Harvest Cycle)

Induction

LED

2nd Harvest Cycle (Days 30 to 45)

Simply...MORE FOOD at less cost of energy.
FURTHER ADVANCEMENTS

Designs for Fixture Optimization
Current LED Grow Lights for Basil on 8’ x 4’ Grow Rack

Wavelength Mix: Red: 6 Blue: 1

The Basil appears to grow more under the blue LEDs when the lights are not raised as the plants grow, so the following strategies refine the ratio.
Testing Analysis: Wavelength Mix

Plant: Basil
Study Sector: Leafy Green Vegetables

Proposed A:
Red: 5
Blue: 2

LED Grow Lights for Basil on 8’ x 4’ Grow Rack

Proposed B:
Red: 4
Blue: 3
Testing Analysis: Wavelength Mix

Plant: Basil
Study Sector: Leafy Green Vegetables

Proposed C:

Red: 1
Blue: 1

LED Grow Lights for Basil on 8’ x 4’ Grow Rack

These two fixtures provide an equal split across the red and blue wavelengths. The linear modules are identical but inverted to provide the stagger effect.
Independence LED has developed custom reflectors for high bay applications and sees strong potential to deploy the technology for the Grow Light series.

The reflectors have the ability to increase the amount of light to accelerate growth or reduce electricity consumption... or both.

The following page includes a schematic fixture system.
This custom design and engineering approach takes the “fixture” to an advanced grow system level, specifically for 8’ x 4’ Grow Racks.

The system includes:

#1: Even diode distribution across Red and Blue wavelengths

#2: Even output distribution across the Grow Rack

#3: Reflector integration for increased performance.
Since the beginning of agriculture, humankind has learned to adapt different types of plants to a range of soil and climate conditions. The Independence LED advanced grow light system with the linear reflectors lends itself to linear plant placement vs. grid layouts.

As the company expands its R&D, lighting systems with complimentary grow layouts may play an increasingly larger role in developing total integrated solutions.
Independence LED develops custom Printed Circuit Boards (PCB) to address the output needs of different plants as well as building conditions.
Ongoing exploration of LED technology specifically for the following:

**Leafy Green Vegetables:**
Development of LED luminaires and smart control systems for leafy Greens: Basil + Arugula, Kale, etc.

**Top Health Benefits of Kale:**
“The Ultimate Superfood”


**Main Stream Vegetables:**
Development of LED luminaires and smart control systems for vegetables such as cucumbers, peppers, squash, etc. The R&D will also include dwarf vegetable plants.

**Main Stream Fruits:**
Development of LED luminaires and smart control systems for fruits such as berries, pears, melons, etc. The R&D will also include dwarf fruit plants.
Additional Growth Opportunities: Niche Vegetables, Fruits, Flowers and Algae

Ongoing exploration of LED technology specifically for the following:

**Niche Vegetables and Fruits:**
Development of LED luminaires and smart control systems for “exotic” Chinese fruits and vegetables that are typically imported to the US for target markets such as Chinatown in New York and San Francisco.

**Algae:**
Development of underwater LED luminaires and smart control systems for bio fuel production.
Ongoing exploration of LED technology specifically for the following:

**Support Technology for Grow Systems:**
Review of existing grow racks, water circulation, pump systems, nutrient additives for soil and hydroponics, and control software. These are all key to successful harvests and specialized by plant type. Independence LED aggregates best practices to provide end users with a suite of “solutions” that it may provide in most cases through strategic relationships with third party manufacturers and consultants.

**In-Office Campus and/or School Applications:**
Development of turn-key “Grow Systems” for green minded corporation and schools to have on site in their cafeterias in addition to the industrial systems for professional indoor farmers.

**Residential Home Applications:** Development of smaller scale turn-key “Grow Systems” and home kit LED lights for green minded home owners to install in basements or garages.
INTRODUCTION

LED GROW LIGHT

S.T.E.M. PROGRAMS

(Science, Technology, Engineering, and Math)

For Schools
As global population rises and life expectancy increases, the world has a growing appetite for:

FOOD     WATER     FUEL

Energy-efficient LED grow light technology can serve as a key part of an integrated solution.
Challenges:

• The food, energy, and water security nexus is an increasing concern around the world.
• Loss of arable soil and clean water, and the continuing increase in global population will result in even greater needs for more food production.
• Indoor agriculture like greenhouses, hydroponics, aquaponics and aeroponics will be crucial in providing proper nutrients for the entire world.

Solutions:

• When students learn about LED grow light systems, they will be more likely to utilize the knowledge in their communities and to grow their own food.
  • This is specifically important in urban communities where “food desserts” are a major issue.
• This STEM program will not only assist students in better nutrition but also benefit the environment.
  • By growing their own food, the students will be more inclined to eat the vegetables that they have created.
The Testing Report with curriculum content ideas that supports this file is available online as a download here:
http://independencel-ed.com/led-grow-lights/

This file profiles THREE System Options, and custom configurations are available upon request:

Small Scale:
8’ long x 1’ wide - Vertical
Ideal for science classrooms for installing along a wall.

Medium Scale:
8’ long x 4’ wide – Horizontal (1 Grow Bed Rack)
Ideal for science classrooms with enough room.

Large Scale:
16’ long x 20’ wide – Horizontal (10 Grow Bed Racks)
Ideal for schools that want to feed their students fresh, organic vegetables, grown locally right on campus.
Small Scale:
8’ long x 1’ wide - Vertical
Ideal for science classrooms for installing along a wall.

STEM - Small Scale Kit includes:
LEDs: (4) 8’ Linear modules with drivers
**LED Cost Range: $600 to $800**
(Subject to Wavelength and Diode Density)

Hydroponic and Agriculture Options:
PCV pipes and PVC connections, mounting and light suspension equipment, lighting timer, power cords, water basin, water pump, net-cups, seeds, nutrients, and grow medium

www.IndependenceLED.com
Medium Scale:
8’ long x 4’ wide – Horizontal (1 Grow Bed Rack)
Ideal for science classrooms with enough room for a 32 sq ft

STEM - Medium Scale Kit includes:
LEDs: (8) 8’ Linear modules with drivers
**LED Cost Range: $1,200 to $1,600**
(Subject to Wavelength and Diode Density)

Hydroponic and Agriculture Options:
Commercial Hydroponics Equipment (e.g. Crop King NFT)
PCV pipes and PVC connections, mounting and light suspension
equipment, lighting timer, power cords, water basin, water pump,
net-cups, seeds, nutrients, and grow medium

www.IndependenceLED.com
Large Scale:
16’ long x 20’ wide – Horizontal (10 Grow Bed Racks) 320 sq ft
Ideal for schools that want to start feeding their students:

STEM - Large Scale System includes:
LEDs: (80) 8’ Linear modules with drivers
**LED Cost Range:** $12,000 to $16,000
(Subject to Wavelength and Diode Density)

Hydroponic and Agriculture Options:
Industrial Hydroponics Equipment and support equipment
(TBD based on facility) *Contact Us for recommendations as well as the calculations on the annual food production yield.*
Sample Curriculum:
Students and faculty can engage in research for some of the following:

• Optimal ratios of daylight to rest per plant type (e.g. 16 hours on with 8 hours of rest, 8 on with 4 off, 4 on 4 off, 2 on 2 off, and many other variables...)

• Advantages of mimicking sunrise and sunset with dimmable LEDs

• Fixed height of LEDs above the plant canopies compared to elevation as the plants growth
Students and faculty can also research some of the following:

• Wavelength mix of red, blue, green, deep red, infrared, and white LED diodes for experimentation to discover which combinations work best with certain plants. There is very limited research on this so it is a wonderful opportunity.

• Linear module density from 1 or 2 per 4 foot area up to 16 linear high density output. Students can find the point at which too much light either does not increase the growth or actually hurts the plants by “burning” the leaves. This is the same case for the hours of illumination.
Students and faculty can also research some of the following:

• Lighting from the side and below as well as from above. This is a very exciting opportunity to advance what mother nature can do. The linear modules are flexible for positioning facing up from the side and on angles. This is one more way for students to test the optimization path. As an example, perhaps less electricity can be used to grow plant if a portion of the light is from the sides vs 100% overhead. This is the type of STEM Challenge that we envision so that schools could compete to find optimization solutions like in the Robot Challenges or Science Fairs.
Students and faculty can also research some of the following:

- Reflectors: Students can test different bean angle performance

- Measurement testing: Many options from root length, plant height and width to weighing leaves and stalks with sub-sets. This is great for math education to model performance metrics
Students and faculty can also research some of the following:

- Post harvest testing: Taste, texture, leaf thickness, shelf life with and without refrigeration, all relative to vegetables purchased at a grocery store/market or control tests with fluorescent tubes vs LEDs as well as comparison to roof top or side yard garden/greenhouse production. mother nature vs Technology Test. Can LEDs outperform mother nature?
Research Time/Schedules
Sample grow light schedule: 28 days for lettuce gives many “scenario” opportunities for a teacher over each semester. Microgreens grow in under 18 days!
NEXT STEPS

Contact Us:
http://independencedled.com/contact/
info@independnenceled.com
484-588-5401

LED GROW LIGHT

S.T.E.M. PROGRAMS
Early Fixture Results

• Fixture Diode “Mix” and PAR
• Specification Sheets and Testing Reports
  Vegetation
  Flowering
• Grow Testimonial – Taproom Kitchen
• Grower Case Study - Great Oak Farms
Fixture Diode “Mix” Options

Modular System: Custom Wavelength Options
Generation 1 Left, Vegetation Center and Flowering Right
Note: The lower set of images are photographed to highlight diode color differences.
The ability of a plant to absorb light **varies with species** and environment.

The general measurement for the light quality as it affects plants is the **PAR value**, or **Photosynthetically Active Radiation** (i.e. the actual light energy that is of value to the plant to promote growth.)

Visible lighting levels are quantified as the amount of radiation in the wavelength range from PAR 400 to 700 nm (nanometer). It can be expressed in units of energy flux (Watts/m$^2$) or photon flux (mol / (m$^2$ s)).

Analogy: **Energy flux is like the energy of the water coming out of a pipe (how hard it is coming out), and Photon Flux is like the number of water molecules that are coming out. Photons are like the water molecules.**
Specifications (12/24/2014)

1. High quality Lumiled Rebel colored LEDs (>50K hrs)
2. Blue (1) - 450nm
3. White (1) - 6500K
4. Deep Red (4) - 660nm
5. Optical Performance

<table>
<thead>
<tr>
<th>Height (in)</th>
<th>PPFD (μmol/m²/s) @ nadir</th>
<th>FWHM - 120°</th>
<th>FWHM - 80° (reflector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>545</td>
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<tr>
<td>18</td>
<td>396</td>
<td>491</td>
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<tr>
<td>24</td>
<td>240</td>
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</tbody>
</table>

6. Total System Power - 380W
7. Size - 18” X 48”
8. Operation - 20°C to 60°C
9. 100-277VAC 50/60 Hz
10. Warranty - 5 years
## Specification Sheets and Testing Reports

### VEGETATION

### Spectral Power Distribution

<table>
<thead>
<tr>
<th>λ(nm)</th>
<th>mW/nm</th>
<th>λ(nm)</th>
<th>mW/nm</th>
<th>λ(nm)</th>
<th>mW/nm</th>
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<td>103</td>
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<td>643</td>
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<tr>
<td>500</td>
<td>42.6</td>
<td>572</td>
<td>102</td>
<td>644</td>
<td>855</td>
</tr>
</tbody>
</table>

### Additional Data Available Upon Request

Left Columns: Gamma(nm) = Color Wavelength (e.g. units of red)

Right Columns: milliwatts/nm = Amount of Energy

[www.IndependenceLED.com](http://www.IndependenceLED.com)
Specifications (12/24/2014)

1. High quality Lumiled Rebel colored LEDs (>50K hrs)
2. Blue (3) - 450nm
3. White (2) - 6500K
4. Red (3) - 625nm
5. Deep Red (5) - 660nm
6. IR (1) - 730nm
7. Optical Performance

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<tr>
<th>Height (in)</th>
<th>PPFD (μmol/m²s) @ nadir</th>
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<td>24</td>
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</table>

PPF - 1.63 (μmol/J)
8. Total System Power - 425W
9. Size - 18" X 48"
10. Operation - 20°C to 60°C
11. 100-277VAC 50/60 Hz
12. Warranty - 5 years, UL, FCC, CE (drivers only)
### Spectral Power Distribution

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Additional Data Available Upon Request

[www.IndependenceLED.com](http://www.IndependenceLED.com)

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FLOWERING

2 Fixtures at 12”
on 4’ x 8’ Planting Surface

1 = PAR 42.26
15 = PAR 634
12 = PAR 507
9 = PAR 380
6 = PAR 253

Specification Sheets and Testing Reports

wwwIndependenceLED.com
Specification Sheets and Testing Reports

FLOWERING

2 Fixtures at 12”
on 4’ x 8’ Planting Surface
1 = PAR 42.26

15 = PAR 634
12 = PAR 507
9 = PAR 380
6 = PAR 253

Independence LED

Competing LED

www.IndependenceLED.com
FLOWERING

2 Fixtures at 12” on 4’ x 8’ Planting Surface

1 = PAR 42.26

15 = PAR 634
12 = PAR 507
9 = PAR 380
6 = PAR 253
“INDEPENDENCE LED Lighting Teams Up with Taproot Kitchen, a Community Center and Culinary Workshop for Special Needs Individuals in the State College Area

In September of 2016, Izaiah Bokunewicz, a freshman at The Pennsylvania State University, thought that it would be an excellent idea to design and construct a vertical farming system at Taproot Kitchen, in State College, PA. After constructing a re-circulating hydroponic system, Izaiah reached out to Independence LED about their LED Grow Lights. Independence LED loved learning about Taproot Kitchen and graciously donated four 8’ fixtures, to complete the vertical farming system that now demonstrates indoor agricultural technologies to the State College community and produces fresh leafy-greens at Taproot’s Kitchen.”
"In early 2016, Izaiah Bokunewicz, a senior at State College Area High School learned about Taproot Kitchen from Dr. U.B. Bakker, a retired professor in Agricultural Leadership at Penn State. At that time, Izaiah was constructing an indoor agricultural system to grow lettuce and spinach for the State College High School cafeteria. After completing a successful vertical farming system at his high school, many people began asking about the possibility of a hydroponics system at Taproot Kitchen. Nothing would be cooler than growing leafy greens in sustainable hydroponics, five seconds away from a kitchen! In July, Izaiah completed construction of another hydroponics system through donations from The Home Depot, Patton Twp. with help from individuals in Taproot Kitchen.

Earlier in June, Izaiah was researching companies that produced the most efficient technologies for sustainable agricultural systems and that is when he learned about Independence LED. PA-made, energy-efficient, and an advocate for local food production with sustainable methods, Izaiah met personally with Independence’s CEO, Charlie Szoradi. After learning about Taproot Kitchen, Independence LED donated four eight-foot LED vegetative grow lights to complete Taproot’s indoor system. Since November 7th, basil, lettuce, mustard greens, and beet microgreens, have been growing in the new system. LED lights shine for sixteen hours each day in a closed-loop hydroponic system. Taproot’s leafy greens are growing successfully and in three weeks, the first harvest will take place, where afterwards, the harvested greens will be prepared by individuals from Taproot Kitchen, to make fresh, tasty salads. Indoor agriculture with Independence LED lights is the latest example of how Taproot Kitchen has brought together many in the State College community to do great things."
Grow Testimonial - Taproom Kitchen, State College, PA
Grower Case Study - Great Oak Farms

**Testing Condition:**
LED Supplement to Natural Light

**Test Site:** Attached Green House/Solarium

**LED Fixture:** Independence LED Vegetation Fixture

**Natural Light:** Dawn to Dusk

**LED Supplemental Light:** 6 am to 7 pm  
(approximately mirroring sunlight)

**Start Date:** Week 1 February 2015

**Plants:**
- Broccoli
- Tomatoes
- Dill
About Great Oak Farm, LLC

Woman Owned family farm - founded 2011 in Virgilina, VA

Great Oak is a “Better than Organic” farm as they do not use any chemical fertilizers, herbicides or other chemicalized agriculture short cuts.

Great Oak farm is a premium producer of Grass fed Grass Finished Beef, Pastured Pork, Cage Free “Better than Fresh” eggs, and seasonal vegetables.

The garden soils are comprised of composted manures and organic materials. Their region is known for clay and rocks.
Grower Case Study - Great Oak Farms

The following feedback is from Donald Wright, Great Oak Farms

**Broccoli** was started February 2\textsuperscript{nd} and germinated within 4 days. Plant seedlings after germination grew very quickly light. Plant stems, leaves and stalks were beautifully colored and very sturdy.

The leaves quickly became broad and plant stems were very strong versus our previous efforts without a grow light.

Previous efforts without a grow light normally produced very spindly plant stalks and slow growth. Plants were prone to fall over in temperature extremes.

The Independence LED Grow Light tests produced plants that were able to withstand temperature fluctuations of 20 to 30 degree differences during cold February months in the Solarium Greenhouse.

The Broccoli was transplanted to the outside garden in Mid March, and the plants continued to grow very well.
Grower Case Study - Great Oak Farms

**Tomatoes and Dill** were started at roughly the same time as the Broccoli over the first week of February.

Use of heating pad and Biochar Soil Reef with Independence Grow Light produced great results with quick and sturdy plant growth similar to the Broccoli.

It is important to note that plants grew very well in locations that had less than ideal stable temperatures and during the coldest months of the end of the winter.

The Tomatoes flowered in as early as the first week of April, which is well in advance of previous growth without the Independence LED fixtures.
The Independence LED Grow lights produced **fast growth** from seedling to transplantable plant.

The LEDs fostered vigorous and broad plant root structure which led to successful transition from seedbed tray to larger individual plant tray

90+% successful seed germination with use of Independence LED and Soil Reef Biochar

Climate fluctuating during cold winter required use of heating pads to support seed germination.

Independence LED Grow lights were initially set up within 4” of the seedlings

Seed starter - Biochar Soil Reef and plastic sectional trays and open trays.

No additional soil was used- exclusively Soil Reef Biochar
Grower Testimonials - Great Oak Farms

Early leaves and robust root growth:
2016 Modular Systems
for large scale indoor farming

Our linear system is ideal for commercial grow operators
with or without greenhouses, clearstory, or sky lights.
2016 Modular Systems
for large scale indoor farming

Our linear system outperforms “fixtures” by delivering the most even light distribution with the lowest initial cost of equipment and the lowest ongoing cost of operation. This naturally maximizes your ROI.
A foundation of success
preceding the launch of the Grow Light Series

About Us

The following pages include Independence LED highlight background information and market traction in general building illumination
10 Reasons *why Independence LED is the preferred choice in the LED Tube and Fixture marketplace.*

Independence LED is a leading U.S. Manufacturer of award winning high-efficiency LED tube retrofit kits and fixtures that replace the less efficient fluorescent tubes, troffers, parking garage fixtures and industrial high bays that dominate commercial lighting. The Company is committed to building the highest quality and most reliable “Mission Critical” commercial and industrial LED lighting products on the market.

In 2010, Independence LED moved its manufacturing from China to southeastern Pennsylvania. The Company has installations across the Fortune 100 from Morgan Stanley to MetLife and in the public sector from multiple NAVY ships to the first Veterans Affairs Hospital. Independence LED has patent filings in over 40 countries and provides a 10 Year Warranty that is the strongest coverage on the market. In addition to winning the Green Business of the Year in 2011, the Company’s LED tubes won the 2013 Best Lighting Retrofit by the US Green Building Council’s Urban Green Award.

Independence LED plays an increasing role in the Global Energy Revolution.

www.IndependenceLED.com
2013 Winner
Best Lighting Retrofit

LED PERFORMANCE: 50% to 65% Savings

Old Tubes: Fluorescent

New Tubes: LED

32 Watts
20,000 Hour Life
(7 years)

12 Watts
60,000 Hour Life
(20 + years)

2011 GREEN BUSINESS OF THE YEAR

www.IndependenceLED.com
PUBLIC SECTOR
Energy Savings

Sample Market Traction

From the U.S. NAVY’s Military Sealift Command (MSC)

to the first Veterans Affairs (VA) Hospital + GSA Schedule

Welcome to the Durham VA Medical Center
PRIVATE SECTOR
Energy Savings
Sample Market Traction
Morgan Stanley

New LED vs. Existing

www.IndependenceLED.com