City of FRESNO REPORT TO THE CITY COUNCIL

AGENDA ITEM NO.	1E
COUNCIL MEETING	3/27/14
APPROVED BY	
DEPARTMENT DIRECTOR	[signature]
CITY MANAGER	[signature]

DATE: March 20, 2014

FROM: JERRY P. DYER, Chief of Police
Police Department

BY: MICHAEL W. BROGDON, Lieutenant
Police Department - Investigative Services Division

SUBJECT: Amend the Fresno City Municipal Code to Repeal Article 21 of Chapter 12, and add Article 21 of Chapter 12, prohibiting the cultivation of Marijuana in All Zone Districts within the city of Fresno

RECOMMENDATIONS

Staff recommends that the City Council approve the amendment to the current Municipal Code by repealing Article 21 of Chapter 12, and adding Article 21 of Chapter 12, prohibiting the cultivation of marijuana in all zone districts within the city of Fresno.

EXECUTIVE SUMMARY

On June 28, 2012, Council adopted Bill Number B-12, Ordinance Number 2012-13, which added Article 21 to Chapter 12 to the Fresno Municipal Code. Section 12-2103 prohibited the outdoor cultivation of marijuana and did not place a prohibition on the indoor cultivation and/or within an outdoor fully-enclosed and secured structure, approved by special permit. However, this past year, 317 marijuana grow complaints (some indoor operations) were investigated by the Police Department's Narcotics Section, with approximately 5,031 pounds of marijuana being seized. Since the outdoor cultivation of marijuana is currently prohibited, adopting this ordinance would prohibit <u>all</u> indoor and outdoor cultivation of marijuana, and thus, minimize the crime and violence which is exposing the surrounding residents to a higher risk of harm.

BACKGROUND

On June 28, 2012, the Council adopted Bill Number B-12, Ordinance Number 2012-13, which added Article 21 to Chapter 12 of the Fresno Municipal Code. Section 12-2103 prohibited the outdoor cultivation of marijuana and did not place a prohibition on indoor cultivations and/or within an outdoor fully-enclosed and secured structure, approved by special permit.

This past year, 317 marijuana grow complaints were investigated by the Fresno Police Department's Narcotics Section with approximately 5,031 pounds of marijuana being seized.

Presented to City Council
Date 3/20/14
Disposition approved
B-17 introduced
and laid over.

A number of marijuana cultivations investigated were indoor operations. Severe damage to these residences was found; especially in the large indoor grows. Carpets removed to the bare floor, windows boarded up, and walls removed or modified. Large grow lamps suspended from the walls and ceilings creating high levels of heat with dangerous electrical alterations, both inside the residence and at the service meter were found. Fans and ventilation ducts were made through the walls and to the roofs to vent humidity and heat. Noxious odors were common both inside and outside the residences.

Marijuana grows attract crime and associated violence. In 2013, we had four (4) armed home invasion robberies related to the cultivation of marijuana. The cultivation of marijuana and/or proceeds of marijuana sales were the primary motive for these robberies. Countless other grows have gone unreported but were later discovered as the result of undercover operations. These indoor grows expose the surrounding residents to a higher risk of harm, especially in cases when an innocent home owner is accidentally targeted.

The State of California provides a limited criminal defense to the cultivation, possession, and use of marijuana for medical purposes. This was created through the adoption of the Compassionate Use Act (CUA). However, the CUA does not address the land use or other impacts that are caused by the cultivation of marijuana.

The Medical Marijuana Program Act (MMPA) establishes a statewide identification program that provides a limited criminal defense to the transportation, processing, administering, and distributing of marijuana to qualified patients, their primary caregivers, and persons with identification cards. However, this act does not create the right to cultivate marijuana.

The Federal Controlled Substance Act (FCSA) makes it unlawful for any person to cultivate, manufacture, distribute, dispense, or possess with intent to manufacture, distribute or dispense marijuana. The FCSA contains no statutory exemption for the possession of marijuana for medical purposes.

The City has a compelling interest in protecting the public health, safety, and welfare of its residents and businesses and in preserving the peace and quiet of the neighborhoods in which marijuana is currently grown. The outdoor cultivation of marijuana is currently prohibited. Adopting this ordinance would prohibit <u>all</u> indoor and outdoor cultivation of marijuana.

A violation of the new ordinance shall be prosecuted by the Fresno City Attorney through the civil enforcement process. The administrative citation penalty for each and every marijuana plant cultivated in violation of this article shall be one thousand dollars ($1,000.00) per plant, plus one hundred dollars ($100.00) per plant, per day the plant remains unabated past the abatement deadline set forth in the administrative citation. Any property upon which a violation of this article is found shall be subject to immediate abatement by the City.

In addition to any administrative penalty assessed for violation of this article, any person found in violation of this article will be charged abatement, actual, administrative and enforcement costs as defined in Section 1-503, calculated to recover the total costs incurred by the City in enforcing this article.

Upon final passage, this ordinance shall be immediately enforceable as to the indoor and outdoor cultivation of marijuana. Any person legally cultivating marijuana indoors prior to the effective date of Article 21 of Chapter 12 of the municipal code, shall have one hundred and twenty (120) days from the effective date of this article to harvest their crop of marijuana. After the one hundred and twenty day grace period, all of the provisions of Article 21 of Chapter 12 shall be immediately enforceable.

ENVIRONMENTAL FINDINGS

Staff has performed a preliminary environmental assessment of this project and, pursuant to CEQA Guidelines Section 15061(b)(3), has determined that there is no possibility that this project may have a significant effect upon the environment because the outdoor cultivation of marijuana is currently a prohibited use, and this ordinance merely prohibits additional future cultivation of marijuana indoors after the current crop year. This will not result in substantial or potentially substantial adverse change in any of the physical conditions effected by this prohibition, including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. Instead, the prohibition is anticipated to have positive effects on the environment, including helping to reduce water consumption and eliminate offensive odors. Regardless of ability to cultivate, state law provides an alternative for collectives and caregiver to locally provide medical marijuana. Even assuming this might have some effect on cost, economic change is not considered a significant effect on the environment. Therefore, this project is not subject to CEQA.

FISCAL IMPACT

The fiscal impact will include the use of existing staff to enforce the ordinance, which would include staff from the Police Department, Code Enforcement, and the City Attorney's Office. The ordinance does include specific fine amounts for initial violations and unabated plants past the abatement deadline. No revenue estimates are projected should those penalties be assessed and collected.

JPD:MFB
03/20/14

Attachment: Marijuana Cultivation Ordinance

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BILL NO. ___________

ORDINANCE NO. ___________

AN ORDINANCE OF THE COUNCIL OF THE CITY OF FRESNO, CALIFORNIA, REPEALING ARTICLE 21 OF CHAPTER 12 OF, AND ADDING ARTICLE 21 OF CHAPTER 12 TO, THE FRESNO MUNICIPAL CODE RELATING TO MARIJUANA CULTIVATION

WHEREAS, the Council hereby finds that the cultivation of marijuana significantly impacts, or has the potential to significantly impact, the city's jurisdiction. These impacts include damage to buildings in which cultivation occurs, including improper and dangerous electrical alterations and use, inadequate ventilation, increased occurrences of home-invasion robberies and similar crimes and nuisance impacts to neighboring properties from the strong and potentially noxious odors from the plants, and increased crime; and

WHEREAS, according to the Chief of Police, marijuana grows have been operating in the city for several years with minimal local regulation and have been the subject of armed robberies with shots fired, incidents with juveniles and young adults, and arrests for violation of both state and federal laws, including seizure of illegal firearms. Marijuana grows attract crime and associated violence. They are harmful to the welfare of the surrounding community and its residents and constitute a public nuisance; and

WHEREAS, marijuana cultivation in the city poses a threat to the public peace, health and safety. Many marijuana grows have emerged in the city which are very visible to the public, and easily accessible to the public, including children and youths.

There is a threat of violent crime due to the size, location, and monetary value of these mature marijuana grows; and

WHEREAS, it is acknowledged that the voters of the State of California have provided a limited criminal defense to the cultivation, possession and use of marijuana for medical purposes through the adoption of the Compassionate Use Act in 1996 pursuant to Proposition 215 and codified as Health and Safety Code section 11362.5. The Compassionate Use Act (CUA) does not address the land use or other impacts that are caused by the cultivation of marijuana; and

WHEREAS, the CUA is limited in scope, in that it only provides a defense from criminal prosecution for possession and cultivation of marijuana to qualified patients and their primary caregivers. The scope of the Medical Marijuana Program Act (MMPA) commencing with Health and Safety Code section 11362.7, is also limited in that it establishes a statewide identification program and affords qualified patients, persons with identification cards and their primary caregivers, an affirmative defense to certain enumerated criminal sanctions that would otherwise apply to transporting, processing, administering or distributing marijuana; and

WHEREAS, neither the CUA, MMPA, nor the California Constitution create a right to cultivate medical marijuana; and

WHEREAS, it is critical to note that neither Act abrogates the city's powers to regulate for public health, safety and welfare. Health and Safety Code 11362.5(b)(2) provides that the CUA does not supersede any legislation intended to prohibit conduct that endangers others. In addition, Health and Safety Code 11352.83 authorizes cities and counties to adopt and enforce rules and regulations consistent with the MMPA; and

WHEREAS, the Council finds that neither the CUA nor the MMPA preempts the city's exercise of its traditional police powers in enacting land use and zoning regulations, as well as legislation for preservation of public health, safety and welfare, such as this zoning ordinance prohibiting cultivation of marijuana within the city; and

WHEREAS, marijuana remains an illegal substance under the Federal Controlled Substances Act, 21 U.S.C. 801, et seq., and is classified as a "Schedule I Drug" which is defined as a drug or other substance that has a high potential for abuse, that has no currently accepted medical use in treatment in the United States, and that has not been accepted as safe for its use under medical supervision. Furthermore, the Federal Controlled Substances Act makes it unlawful for any person to cultivate, manufacture, distribute, dispense, or possess with intent to manufacture, distribute or dispense marijuana. The Controlled Substances Act contains no statutory exemption for the possession of marijuana for medical purposes. The city does not wish to be in violation of federal law; and

WHEREAS, the city has a compelling interest in protecting the public health, safety and welfare of its residents and businesses, and in preserving the peace and quiet of the neighborhoods in which marijuana is currently grown; and

WHEREAS, staff has performed a preliminary environmental assessment of this project and, pursuant to CEQA Guidelines, Section 15061(b)(3), has determined that there is no possibility that this project may have a significant effect on the environment because the outdoor cultivation of marijuana is currently a prohibited use, and this ordinance merely prohibits additional future cultivation of marijuana indoors after the current crop year. This will not result in a substantial, or potentially substantial, adverse change in any of the physical conditions affected by this prohibition, including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. Instead, the prohibition is anticipated to have positive effects on the environment, including helping to reduce water consumption and to eliminate offensive odors. Therefore, this project is not subject to CEQA.

THE COUNCIL OF THE CITY OF FRESNO DOES ORDAIN AS FOLLOWS:

SECTION 1. Article 21 of Chapter 12 of the Fresno Municipal Code is repealed.

SECTION 2. Article 21 is added to Chapter 12 of the Fresno Municipal Code to read:

ARTICLE 21

CULTIVATION OF MARIJUANA

SECTION 12-2101. PURPOSE AND INTENT. The purpose of this article is to prohibit the cultivation of marijuana in order to protect the public peace, health, safety and general welfare of the citizens of the city.

SECTION 12-2102. RELATIONSHIP TO OTHER LAWS. This article is not intended to, nor shall it be construed or given effect in a manner that causes it to apply to, any activity that is regulated by federal or state law to the extent that application of this article would conflict with such law or would unduly interfere with the achievement of federal or state regulatory purposes. This article shall be interpreted to be compatible and consistent with federal, county, and state enactments and in furtherance of the public purposes which those enactments express. It is the intention that the provisions of this article will supersede any other provisions of this code found to be in conflict.

SECTION 12-2103. DEFINITIONS. For purposes of this article, unless the particular provision or the context otherwise clearly requires, the definitions in this section shall govern the construction, meaning and application of words and phrases used in this article:

(a) "Cultivation" means the planting, growing, harvesting, drying, processing, or storage of one or more marijuana plants or any part thereof in any location.

(b) "Marijuana" means all parts of the plant Cannabis sativa L., whether growing or not, and includes medical marijuana.

(c) "Medical marijuana" means marijuana used for medical purposes in accordance with California Health and Safety Code section 11362.5.

(d) "Collective, cooperative or dispensary" means a collective, cooperative, dispensary, operator, establishment, provider, association or similar entity that cultivates, distributes, delivers or processes marijuana for medical purposes relating to a qualified patient or primary caregiver, pursuant to the Compassionate Use Act and Medical Marijuana Program Act.

(e) "Primary caregiver" means a primary caregiver as defined in Health and Safety Code section 11362.7.

(f) "Qualified patient" means a qualified patient as defined in Health and Safety Code section 11362.7.

SECTION 12-2104. PROHIBITION OF MARIJUANA CULTIVATION. Marijuana cultivation by any person, including primary caregivers and qualified patients, collectives, cooperatives or dispensaries, is prohibited in all zone districts within the city.

SECTION 12-2105. VIOLATION AND PENALTY.

(a) A violation of this article shall be prosecuted by the City Attorney through the civil enforcement process, including injunctive relief, as set forth in Section 1-308 of this code. Each day a person is in violation of this article shall be considered a separate violation.

(b) The administrative citation penalty for each and every marijuana plant cultivated in violation of this article shall be One Thousand Dollars ($1,000) per plant, plus One Hundred Dollars ($100) per plant per day the plant remains unabated past the abatement deadline set forth in the administrative citation.

(c) Any property upon which a violation of this article is found shall be subject to immediate abatement by the city.

(d) In addition to any administrative penalty assessed for violation of this article, any person found in violation of this article will be charged abatement, actual, administrative and enforcement costs as defined in Section 1-503, calculated to recover the total costs incurred by the city in enforcing this article.

SECTION 12-2106. SEVERABILITY. If any section, sentence, clause or phrase of this article is for any reason held to be invalid or unconstitutional by a decision of any court of competent jurisdiction, such decision shall not affect the validity of the remaining portion of this article. The Council hereby declares that it would have passed this ordinance and adopted this article and each section, sentence, clause or phrase thereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses or phrases be declared invalid or unconstitutional.

SECTION 12-2107. APPLICABILITY. All of the provisions of this article shall be immediately enforceable as to the outdoor cultivation of marijuana. Any person legally cultivating marijuana indoors prior to the effective date of this article shall have one hundred twenty (120) days from the effective date of this article to harvest their crop of marijuana. After the one hundred twenty day (120) grace period, all the provisions of this article shall be immediately enforceable.

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SECTION 3. This Ordinance shall become effective and in full force and effect at 12:01 a.m. on the thirty-first day after its final passage.

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STATE OF CALIFORNIA)
COUNTY OF FRESNO) ss.
CITY OF FRESNO)

I, YVONNE SPENCE, City Clerk of the City of Fresno, certify that the foregoing Ordinance was adopted by the Council of the City of Fresno, at a regular meeting held on the ______day of ___________________, 2014.

AYES :
NOES :
ABSENT :
ABSTAIN :

Mayor Approval: ______________________________, 2014
Mayor Approval/No Return: ____________________, 2014
Mayor Veto: __________________________________, 2014
Council Override Vote: _________________________, 2014

YVONNE SPENCE, CMC
City Clerk

BY:_________________________
Deputy

APPROVED AS TO FORM:
CITY ATTORNEY'S OFFICE

BY:_______________________________
Katherine B. Doerr Date
Supervising Deputy

KBD:elb [63853elb/kbd] Ord. 1/30/14

County of Fresno

CHAIRMAN
BOARD OF SUPERVISORS
SUPERVISOR ANDREAS BORGEAS– DISTRICT TWO

March 19, 2014

Council President Steve Brandau
City of Fresno
2600 Fresno Street
Fresno, CA 93721

RE: Marijuana Policy

Dear Council President Steve Brandau,

On January 7, 2014 the Fresno County Board of Supervisors voted unanimously to amend various County ordinances relating to the cultivation of medical marijuana and corresponding penalties. The amended ordinance bans cultivation of medical marijuana, classifies the violation of the ordinance to be a public nuisance, and applies administrative penalties for the cultivation of medical marijuana within the unincorporated areas of Fresno County.

I am thankful for the City/County partnership efforts you have already supported as Council President. It goes without reminding that I strongly encourage the members of the Fresno City Council to adopt counterpart legislation that will help establish a uniform policy between Fresno County and Fresno City. A consistent policy within the incorporated and unincorporated areas of Fresno County will ultimately provide clarity for residents regarding the impermissible cultivation of medical marijuana and make it easier for law enforcement to protect the welfare of the residents and businesses in our community.

Thank you for your support and, once again, I hope the City of Fresno and Fresno County will successfully partner on this very important public safety legislation.

Respectfully,

Chairman Andreas Borgeas

Room 300, Hall of Records / 2281 Tulare Street / Fresno, California 93721-2198 / (559) 600-2000 / FAX (559) 600-1609 / 1-800-742-1011

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Received Less Than
24 Hours Before Meeting
Not Distributed

March 19, 2014

VIA OVERNIGHT MAIL

City Council
City of Resno
c/o Yvonne Spence, City Clerk
2600 Fresno Street
Room 2133
Fresno, CA 93721

Re: Amend the Fresno City Municipal Code to Repeal Article 21 of Chapter 12, and add Article 21 of Chapter 12, prohibiting the cultivation of Marijuana in All Zone Districts within the city of Fresno

Dear Mayor Swearengin and Councilmembers:

The Union of Medical Marijuana Patients ("UMMP") is pleased to comment on the City of Fresno's ("City") proposed Ordinance regarding the cultivation of medical marijuana ("Ordinance" or "Project"). UMMP is in receipt of the materials published on the City's website regarding the Ordinance. In the Staff Report issued for the Project, the City states that "[s]taff has performed a preliminary environmental assessment of this project and, pursuant to CEQA Guidelines, Section 15061(b)(3), has determined that there is no possibility that this project may have a significant effect upon the environment . . . ." Staff Report at p.3. This letter notifies the City that the Ordinance is not exempt from CEQA and outlines the foreseeable environmental effects associated with the Ordinance requiring review and mitigation. Because the Ordinance is not exempt from CEQA pursuant to the common-sense exemption, the City must conduct an Initial Study

321 1/2 E. 1st Street, Suite 200, Los Angeles, CA 90012
213-626-2730 (Phone) 213-613-1443 (Fax)
UnionMMP.org

pursuant to §15063 of the California Public Resources Code before adopting the Ordinance.

About UMMP

I would first like to introduce my organization. UMMP is a not-for-profit civil rights organization that is devoted to defending and asserting the rights of medical cannabis patients. UMMP promotes a model of legally compliant medical cannabis patient associations and has developed a self-regulatory product, AGSite Secure, to ensure all Californians using medical cannabis and forming patient associations have the opportunity to do so with a clear and unambiguous understanding of the law. UMMP is committed to sensible regulations for patient associations and their dispensaries, responsible actions of patients and cooperation with law enforcement.

The Proposed Ordinance:

According to the Staff Report dated March 20, 2014, "adopting th[e] ordinance would prohibit all indoor and outdoor cultivation of marijuana in the City. Staff Report at p. 1.

With regard to CEQA, the Ordinance states the following:

> *"Staff has performed a preliminary environmental assessment of this project and, pursuant to CEQA Guidelines, Section 15061(b)(3), has determined that there is no possibility that this project may have a significant effect upon the environment because the outdoor cultivation of marijuana is currently a prohibited use, and this ordinance merely prohibits additional future cultivation of marijuana indoors after the current crop year. This will not result in a substantial or potentially substantial adverse change in any of the physical conditions effected by this prohibition, including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. Instead, the prohibition is anticipated to have positive effects on the environment, including helping to reduce water consumption and eliminate offensive odors. Therefore, this project is not subject to CEQA."*

Staff Report at p. 3.

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The Ordinance is Not Exempt from CEQA Under the Common-Sense Exemption

The Ordinance is not exempt from CEQA under the so-called "common sense" exemption. CEQA Guidelines Section 15061, Subdivision(b)(3) describes the so-called "common sense exemption," where "[t]he activity is covered by the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the environment. Where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment, the activity is not subject to CEQA" (emphasis added). As a result, the burden of proof rests with the City to demonstrate that the commonsense exemption applies. *Davidson Homes v. City of San Jose* (1997) 54 Cal. App.4th 106, 116 ("[T]he agency must itself provide the support for its decision before the burden shifts to the challenger. Imposing the burden on the members of the public in the first instance to prove a possibility or substantial adverse environmental impact would frustrate CEQA's fundamental purpose of ensuring that governmental officials 'make decisions with environmental consequences in mind.'") Even if an agency has provided support for its decision to exempt a project under the "common sense exemption," the "showing required of a party challenging an exemption under [the commonsense exemption] is slight, since that exemption requires the agency to be certain that there is no possibility the project may cause significant environmental impacts. If legitimate questions can be raised about whether the project might have a significant impact and there is any dispute about the possibility of such an impact, the agency cannot find with certainty that a project is exempt." *Id.*

The Environmental Baseline

Under CEQA, the environmental baseline includes existing patients that cultivate medical marijuana (either indoors of outdoors) for their own personal use in compliance with state law. In June of 2012 the City adopted Ordinance Number 2012-13, which prohibited the outdoor cultivation of marijuana, but did not place a prohibition on the indoor cultivation and/or within an outdoor fully-enclosed and secured structure, approved by special permit. Staff Report at p. 1. As a result, patients were required to either cultivate medical marijuana in their own home or travel outside the City to obtain medical marijuana.

The environmental baseline also includes an estimated patient population of 10,117 persons in the City. This is based on an analysis conducted by Cal. NORML, another medical marijuana advocacy organization, concluding that that the patient base in California is 2-3% of the overall population. (*See* Exhibit 1). The legality of cultivation in the City does not relieve the City with the obligation to such operations in the environmental baseline. In *Riverwatch v. County of San Diego* (1999) 76 Cal. App.4th 1428, 1451, the court held that the proper baseline is the existing condition of the site, even if that condition may be the result of prior illegal activity. The court explained in *Riverwatch* that CEQA is not "the appropriate forum for determining the nature and consequence of a prior conduct of a project applicant." 76 Cal. App.4th at 1452. The decision in *Riverwatch* has been followed by other courts. *See Eureka Citizens for Responsible Government v. City of Eureka* (2007) 147 Cal. App. 4th 357, 370 (citing *Riverwatch* and stating that the "environmental impacts should be examined in light of the environment as it exists when a project is approved").

Moreover, it is a fundamentally accepted principle that environmental impacts should be examined in light of the environment as it exists when a project is approved. (Guidelines, § 15125, subd. (a); *Bloom v. McGurk* (1994) 26 Cal. App. 4th 1307, 1315, fn. 2; *City of Carmel-by-the-Sea v. Board of Supervisors* (1986) 183 Cal. App. 3d 229, 246; *Christward Ministry v. Superior Court* (1986) 184 Cal. App. 3d 180, 190; *Environmental Planning & Information Council v. County of El Dorado* (1982) 131 Cal. App. 3d 350, 358; Remy et al., Guide to the Cal. Environmental Quality Act (10th ed. 1999) p. 165.) In this case, there are an approximate 1,184 medical marijuana patients in the City, many of whom cultivate their own medical marijuana due to the ban of "medical marijuana dispensaries" in the City.

The Ordinance is a "Project"

As an initial matter, it should be noted that the Ordinance is a "project" under CEQA. The fact that the "project" at issue is the adoption of an ordinance as opposed to a development project proposed by an applicant does not relieve the City of the obligation to undertake a review of the project under CEQA. *Rosenthal v. Board of Supervisors* (1975) 14 Cal.App.3d 815, 823 (stating that "adopting an ordinance [is] a project"); *No Oil, Inc. v. City of Los Angeles* (1974) 13 Cal.3d 68, 118 Cal.Rptr. 34 (impliedly holding that adoption of ordinance is a project within the meaning of CEQA); 60 Ops.Cal.Atty.Gen. 335 (1977) ("ordinances and resolutions adopted by a local agency are 'projects' within the meaning of CEQA"). The Attorney General Opinion issued in 1977 concluded that the following ordinances were all subject to CEQA: (1) an open-range ordinance requiring private landowners to fence out cattle; (2) an ordinance allowing construction of single family dwellings in rural areas without electricity, running water, or flush toilets; and (3) an ordinance modifying road improvement standards for new subdivisions. The bottom line is that a project need not directly affect a physical change in the environment; reasonably foreseeable indirect or secondary effects must also be analyzed. The relative inquiry is whether or not the project, or in this case, the Ordinance, will ultimately culminate in physical changes to the environment. *Id.*

Additionally, it should be emphasized that "[w]hether an activity constitutes a project subject to CEQA is a categorical question respecting whether the activity is of a general kind with which CEQA is concerned, without regard to whether the activity will actually have environmental impacts." *Muzzy Ranch Co. v. Solano County Airport Land Use Commission* (2007) 41 Cal.4th 372, 381. It is well established that the enactment of a zoning ordinance such as the Ordinance proposed by the City is subject to environmental review under CEQA. *See, e.g., Concerned Citizens of Palm Desert v. Board of Supervisors* (1974) 38 Cal.App.3d 272, 283 (the "enactment and amendment of zoning ordinances" are subject to CEQA).

Here, the City is committing itself to a particular approach to regulating medical marijuana - an extremely restrictive approach that, among other things, requires of patients to drive to other cities to obtain their medicine because both medical marijuana dispensaries and cultivation are banned in the City.

As previously noted, there are an estimated 10,117 patients in Fresno. Further, it may be fairly assumed that each of them will need to go to a dispensary approximately once a week to get their medicine. However, the nearest storefront medical marijuana dispensary from Fresno is 109 miles away in Bakersfield. Therefore, the City's ban of all cultivation would result in weekly increase of 2,205,506, or an annual increase of 115,001,384 in miles traveled. Based upon Federal Statistics, this would result in approximately 48,869 metric tons per year in CO2 emissions alone. It would also be expected to generate 49,145 pounds of Reactive Organic Gasses, 36.86 tons of Nitrous Oxide and 82.93 tons of PM10 per year. (*See*, e.g., EPA Fact Sheet entitled "Greenhouse Gas Emissions from a Typical Passenger Vehicle" attached as Exhibit 2.) Clearly, the Ordinance will result in increased travel and air pollution, which nevertheless could create environmental impacts, such as traffic and air pollution, within the City. The City has failed to conduct an analysis of the environmental consequences of the draconian approach of the Ordinance to regulating medical marijuana.

<u>The City Has Failed to Consider the Significant Environmental Impacts of the Ordinance</u>

Moreover, the Ordinance's ban on cultivation shifts the development impacts associated with cultivation to other jurisdictions, which the City has failed to analyze. It is reasonably foreseeable that cultivation of medical marijuana in other cities and counties will increase due to the ban. Cultivation of medical marijuana, an inherently agricultural activity, especially in a residential setting, in and of itself contemplates environmental impacts, which the City has failed to analyze. Consider the following: Assuming patients use 1 ounce of marijuana per month, then 7,587 pounds of cannabis per year would need to be cultivated to meet patient needs in the City.

Much of the displaced cultivation created by the ban may occur indoors and there are environmental impacts associated with indoor cultivation that may be significant. A recent study entitled *The Carbon Footprint of Indoor Cannabis Production*, published in The International Journal of the Political, Economic, Planning, Environmental and Social Aspects Energy, detailed the environmental impacts of indoor cannabis cultivation. (*See* Exhibit 3). The following are highlights from the study:

- On average, approximately one third of cannabis production takes place under indoor conditions. Approximately two-thirds of all cannabis is produced outdoors.
- In California, 400,000 individuals are authorized to cultivate cannabis for personal medical use, or sale for the same purpose to 2100 dispensaries.
- One average kilogram of cannabis is associated with 4600 kg of carbon dioxide emissions (greenhouse-gas pollution) to the atmosphere, a very significant carbon footprint, or that of 3 million average U.S. cars when aggregated across all national production.
- Indoor cannabis production utilizes highly energy intensive processes to control environmental conditions during cultivation.
- Indoor cultivation also results in elevated moisture levels that can cause extensive damage to buildings as well as electrical fires caused by wiring out of compliance with safety codes.
- Indoor carbon dioxide levels are often raised to 4-times natural levels to boost plant growth when cannabis is cultivated indoors.
- Indoor cannabis production results in electricity use equivalent to that of 2 million average U.S. homes. This corresponds to 1% of national electricity consumption.
- In California, the top-producing state, indoor cultivation is responsible for about 3% of all electricity use or 9% of household use. This corresponds to greenhouse-gas emissions equal to those from 1 million cars.

- Accelerated electricity demand growth has been observed in areas reputed to have extensive indoor Cannabis cultivation. For example, after the legalization of medical marijuana in 1996, Humboldt County experienced a 50% rise in per-capita residential electricity use compared to other parts of the state.
- Shifting cultivation outdoors can nearly eliminate energy use for the cultivation process. However, outdoor cultivation creates its own environmental impacts. These include deforestation; destruction of wetlands, runoff of soil, pesticides, insecticides, rodenticides and human waste; abandoned solid waste; and unpermitted impounding and withdrawals of surface water. These practices can compromise water quality, fisheries and other ecosystem services. However, outdoor cultivation can compromise security.

This study was the product of previous research conducted by the same author. (*See* Exhibit 4). Additional research has confirmed these impacts. (*See* Exhibit 5). The City has completely failed to analyze the Ordinance's reasonably foreseeable environmental impacts, specifically the impacts of indoor cultivation in other jurisdictions. The Ordinance is not exempt from CEQA and there are significant environmental impacts, as outlined in the aforementioned studies, that the City has failed to mitigate that implicate agriculture, air quality, water quality, traffic, land use planning, etc.

Cultivation of medical marijuana indoors, including in single-family residential zones, implicate significant environmental concerns and require meaningful review under CEQA. Obviously, cultivation of medical marijuana to meet existing patients demand will need to take place outside City limits as a result of the Ordinance (in fact, outside of the County due to the ban on cultivation by the County of Fresno) and additional waste water will be created as a result of these cultivation activities. Moreover, additional waste plant material (a.k.a bio-waste) will be created that must be disposed of properly. However, because these activities may take place indoors, the proper means of disposal is unclear and the City has failed to mitigate the foreseeable environmental impacts. Indeed, state regulatory agencies, including, for example, the Central Valley Regional Water Quality Control Board (CVRWQCB), have recognized the environmental consequences of cultivation and recently issued a notice and fact sheet to cultivators in an effort to prevent environmental damage. (*See* Exhibit 6).

Further, and as noted above, there will also be an increase in the electrical consumption that will be required. These facts are compelling and demonstrate potential significant environmental effects in terms of (1) Greenhouse Gas Emissions, (2) Hazards & Hazardous Materials, (3) Hydrology/Water Quality, and (4) Utilities/Service Systems.

<u>The Ordinance Creates New Environmental Harms and Therefore Is Not Exempt from CEQA as an Activity Designed to Protect the Environment Pursuant to CEQA Guidelines Section 15308</u>

Further, the City cannot argue that the Ordinance is exempt from CEQA as an activity "designed to project the environment." It should be emphasized that activities intended to protect or preserve the environment are not automatically immune from environmental review. The Guidelines provide that categorical exemptions may not be used where there is a reasonable possibility that the activity will have a significant effect on the environment (1) when "the cumulative impact of successive projects of the same type in the same place, over time is significant" (Guidelines, § 15300.2(b)), or (2) due to "unusual circumstances." (Guidelines, § 15300.2(c).) *See Dunn-Edwards Corp. Bay Area Air Quality Management Dist.* (1992) 9 Cal.App.4th 644 (overturning amendments to air district regulations designed to reduce the amount of volatile organic carbons in paint for failure to comply with CEQA); *Building Code Action v. Energy Resources Conservation & Dev. Com.* (1980) 102 Cal.App.3d 577 (adoption of emergency conservation regulations establishing double-glazing standards for new residential construction could have significant impact on air quality as result of increased glass production).

Rulemaking proceedings cannot be found exempt, however, when the rule has the effect of weakening environmental standards. [Even a] new regulation that strengthens some environmental requirements may not be entitled to an exemption if the new requirements could result in other potentially significant effects.

California Unions for Reliable Energy v. Mojave Desert Air Quality Management Dist. (2009) 178 Cal.App.4th 1225, 1240 (quoting 2 Kostka & Zischke, *Practice Under the Cal. Environmental Quality Act*, *supra,* § 20.43, p. 981) (internal citations omitted).

Even if a public agency meets its initial burden to show the exemption is supported by substantial evidence, it still has to defend against claims that the exemption is subject to an exception. (*Ibid.*) Thus, it is simply not the case that a city or county can circumvent CEQA merely by characterizing its ordinances as environmentally friendly and therefore exempt under the Class 7 or 8 categorical exemptions.

Save the Plastic Bag Coalition v. County of Marin (2013) 218 Cal.App.4th 209, 228. As explained below, there is no substantial evidence to support the City's conclusion that the Ordinance is exempt from CEQA pursuant to CEQA Guidelines Section 15308.

Conclusion

While the above discussion is not intended to be an exhaustive list of the reasonably foreseeable indirect or secondary effects of the Ordinance, it is illustrative of the types of impacts that the City must analyze. A fair argument has been outlined regarding the significant environmental effects of the Ordinance. As such, the City is compelled to prepare an Initial Study pursuant to §15063 of the California Public Resources Code as there are no applicable exemptions established in Division 13, Articles 18 or 19 of the California Public Resources Code. The Ordinance will have a significant effect on the environment and the City has failed to mitigate these impacts as required under CEQA. As such, the City is required to prepare an Environmental Impact Report. CEQA Guidelines, § 15002, subd. (k); *No Oil, Inc. v. City of Los Angeles* (1974) 13 Cal.3d 68, 74 (If the initial study shows that the project may have a significant effect, the lead agency takes the third step and prepares an Environmental Impact Report.)

Regards,

/s/ James Shaw

James Shaw
Executive Director

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Exhibit 1

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Medical Marijuana Patient Population in CA

Posted May 31st, 2011 by canorml_admin

Cal. NORML
Estimates 750,000 - 1,125,000
Medical Marijuana Patients in California
Retail Medical Market is $1.5 - $4.5 Billion Per Year

May 31st, 2011. California NORML estimates that there are now over 750,000 medical marijuana users in the state, or 2% of the population, according to the most recent data. At the high end, an estimate of over 1,125,000 patients, or 3% of the population, is consistent with the data. This represents a substantial increase from Cal NORML's earlier estimates of 300,000 (in 2007); 150,000 (in 2005); and 75,000 (in 2004); but is in line with registration rates in other comparable states that enjoy similar wide access to medical cannabis clinics and dispensaries.

Because patients are not required to register in California, their exact number is uncertain. Under California's medical marijuana law, Prop. 215, patients need only a physician's recommendation to be legal. Just a tiny fraction of the state's medical marijuana population is enlisted in the state's voluntary ID card program, which issued just 12,659 cards in 2009-10. Therefore, California patient numbers must be estimated from other sources. Among the most salient are medical marijuana registries in Colorado and Montana, which report usage rates of 2.5% and 3.0%, respectively. Because California's law is older and has more liberal inclusion criteria than other states, usage here is likely to be higher.

Despite this, there is no evidence that liberal access to medical marijuana has spurred overall marijuana use in California. According to U.S. SAMHSA data, the total number of users in the state, including non-medical ones, amounts to 6.7% of the population (2.5 million) within the past month, or 11.3% (4.1 million) within the past year. This places California only slightly above the national average in marijuana use (6.0% monthly and 10.4% yearly), and below several states with tougher marijuana laws. Use of marijuana by California school youth has declined since Prop. 215 passed, according to data from the Attorney General's Survey of Student Drug Use in California. The increase in medical marijuana use therefore appears to reflect a tendency for existing users to "go medical," rather than the enlistment of new users.

UPDATE 6/1: In California and nearly every other medical marijuana state in the US, monthly use by teenagers, highway fatalities, and workplace injuries/illnesses are down since the state legalized medical marijuana. (See below)

The total retail value of medical marijuana consumed in California can be estimated at between $1.5 and $4.5 billion per year, assuming a market of 2% to 3% of the population, average use of 0.5 to 1 gram per day, and an average cost of $320 per ounce.

Basis for 2% - 3% Estimate

California's patient population can be estimated from data from other medical marijuana states where patients are required to register, shown in the table below. The top two of these are Colorado and Montana, which, like California, have a well developed network of cannabis clinics and dispensaries, and which report usage rates of 2.5% and 3.0%, respectively. Other states, where medical marijuana is less developed, report lower rates of 1% and less. However, California is likely to be on the high side because it has the oldest and most liberal law in the nation. Significantly, California is the only state that permits marijuana to be used for any condition for which it provides relief - in particular, psychiatric disorders, such as PTSD, bipolar disorder, ADD, anxiety and depression, which account for some 20%-25% of the total patient population [01]. Adjusting for this, usage in California could be as much as 25% to 33% higher than in Colorado and Montana, which would put it well over 3% of the population (1,125,000).

State	Registered Patients	% Population
Colorado [1]	123,890	2.5%
Hawaii [2]	5,190	0.4%
(Hawaii - Oahu	691	0.1%)
(Hawaii - Big Island	3,160	1.7%)
Michigan [3]	63,869	0.6%
Montana [4]	29,948	3.0%
Oregon [5]	39,774	1.0%
Rhode Island [6]	3,073	0.3%

Sources: (1) http://www.cdphe.state.co.us/hs/medicalmarijuana/statistics.html, accessed 5/30/2011; (2) Andrew Pereira, "Number of Medical Marijuana Patients Soars," KHON News, Nov. 13, 2009; (3) "Bringing Clarity to Michigan's Medical Marijuana Law," Detroit Free Press, Apr 3, 2011;
(4) http://www.dphhs.mt.gov/medicalmarijuana/mmphistoricaldata.shtml [Note: eligibility in Montana is due to be restricted under a new law passed in 2011];
(5)http://public.health.oregon.gov/DiseasesConditions/ChronicDisease/MedicalMarijuanaProgram/Pages/data.aspx;
(6) http://www.health.ri.gov/publications/programreports/MedicalMarijuana2011.pdf

A 2%+ patient population estimate is supported by data from the Oakland Patient ID Center, which has been issuing patient identification cards to its members since 1996. The OPIDC serves patients from all over the state, but especially the greater Oakland-East Bay area of Northern California, where its cards are honored by law enforcement. As of 2010, the OPIDC had issued ID's to 19,805 members from five East Bay cities (Oakland, Berkeley, Alameda, Hayward and Richmond), amounting to 2.4% of the local population. Because the cards were issued over a period of 14 years, they include numerous patients who have lapsed, moved, or deceased. On the other hand, they do not include many other local patients who have current recommendations but never registered with the OPIDC.

Even higher numbers have been reported by the Peace In Medicine collective in Sebastopol, Sonoma County, whose members number 3.6% of local residents [02].

Caution is needed in projecting these figures statewide, since usage is subject to substantial local variations. For example, in Hawaii per capita usage is over twenty times higher on the Big Island than on the main island of Oahu. This can be explained by local differences in culture as well as access to cannabis-recommending physicians. California is a heterogeneous state, in which usage is likely to be higher in liberal coastal areas than in the more culturally conservative interior.

Nonetheless, there are sound reasons not to be surprised by medical marijuana usage rates of 2% and more. A poll by Health Canada [03] found that 4% of the population over age 15 used cannabis for medical reasons without government permission; another poll [04] by Toronto's Centre for Addiction and Mental Health found that 2% of Ontario adults used marijuana for medicine.

Marijuana's popularity can be explained by its low toxicity, pleasant effects, and remarkably wide range of therapeutic uses, over 250 of which have been reported. By far the leading application is chronic pain, which accounts for the majority of all recommendations. Studies by California's Center for Medicinal Cannabis Research have shown that marijuana is particularly effective for neuropathic pain, an otherwise difficult to treat condition that afflicts up to 7- 8% of the population. Patients who use marijuana for pain commonly report significant reductions in their use of other medications, in particular prescription opiates.

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Gieringer D. (2003). The acceptance of medicinal marijuana in the U.S. *Journal of Cannabis Therapeutics, 3*(1).

[02] Personal communication: 1,144 patients from zip code 95472 - May, 21, 2011.

[03] Health Canada poll: Ottawa Citizen, "Most 'medical' marijuana use illegal: Poll," Feb 3, 2002.

[04] Toronto CAMH poll: Ogborne, A. et al., "Self reported medical use of marijuana: A survey of the general population", Canadian Medical Association Journal 152:1685-6 (2000).

UPDATE 6/1:

America's One Million Legalized Marijuana Users

May 31st, 2011 By: Russ Belville, NORML Outreach Coordinator

In all medical marijuana states for which we have data:

-Monthly use by teenagers is down in all states but Maine
-Highway fatalities are down everywhere except Rhode Island
-Workplace injuries/illnesses are down everywhere.

In California:

Age 12-17 Monthly Use When Passed	Age 12-17 Monthly Use in 2008	Highway Fatalities When Passed	Highway Fatalities in 2009	Workplace Injuries / Illness When Passed	Workplace Injuries / Illness in 2009
7.70%	6.86%	3,989	3,081	7.1%	4.2%

Click on the number for the data source.

See data for other states.

- Add new comment

Exhibit 2

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Questions and Answers

Greenhouse Gas Emissions from a Typical Passenger Vehicle

The U.S. Environmental Protection Agency (EPA) developed this fact sheet to answer common questions about greenhouse gas emissions from passenger vehicles. This fact sheet provides emission rates and calculations consistent with EPA's regulatory work.

How much tailpipe carbon dioxide (CO_2) is created from burning one gallon of fuel?

The amount of CO_2 created from burning one gallon of fuel depends on the amount of carbon in the fuel. After combustion, a majority of the carbon is emitted as CO_2 and very small amounts as hydrocarbons and carbon monoxide. Carbon content varies by fuel, and some variation within each type of fuel is normal. The EPA and other agencies use the following average carbon content values to estimate CO_2 emissions:

CO_2 Emissions from a gallon of gasoline:	8,887	grams CO_2 / gallon[1]
CO_2 Emissions from a gallon of diesel:	10,180	grams CO_2 / gallon[2]

Vehicles that use diesel fuel generally have higher fuel economy than comparable gasoline vehicles. However, when comparing carbon dioxide emissions, the higher CO_2 emissions from diesel fuel partially offset the fuel economy benefit.

1 This gasoline factor is from a recent regulation establishing GHG standards for model year 2012-2016 vehicles (75 FR 25324, May 7, 2010).

2 This diesel factor is from the calculations that vehicle manufacturers use to measure fuel economy (40 C.F.R 600.113).

United States Environmental Protection Agency

Office of Transportation and Air Quality
EPA-420-F-11-041
December 2011

How much tailpipe carbon dioxide (CO_2) is emitted from driving a mile?

The average passenger vehicle emits about 423 grams of CO_2 per mile. This number can vary based on two factors: the fuel economy of the vehicle and the amount of carbon in the vehicle's fuel. The average gasoline vehicle on the road today has a fuel economy of about 21 miles per gallon.[3] Most vehicles on the road in the US today are gasoline vehicles, and every gallon of gasoline creates about 8887 grams of CO_2 when burned. Therefore, the average vehicle when driving one mile has tailpipe CO_2 emissions of about:

$$CO_2 \textit{ emissions per mile} = \frac{CO_2 \textit{ per gallon}}{MPG} = \frac{8887}{21} = \mathbf{423}\ \textbf{\textit{grams}}$$

What are the average annual carbon dioxide (CO_2) emissions of a typical passenger vehicle?

A typical passenger vehicle emits about 5.1 metric tons of carbon dioxide per year. This number can vary based on a vehicle's fuel, fuel economy, and the number of miles driven per year. The average gasoline vehicle on the road today has a fuel economy of about 21 miles per gallon and drives around 12,000 miles per year. Every gallon of gasoline burned by that vehicle creates about 8887 grams of CO_2, and there are one million grams per metric ton. Therefore, the average vehicle over a year of driving has tailpipe CO_2 emissions of about[4]:

$$\textit{Annual } CO_2 \textit{ emissions} = \frac{CO_2 \textit{ per gallon}}{MPG} \times \textit{miles} = \frac{8887}{21} \times 12000 = \mathbf{5.1}\ \textbf{\textit{metric tons}}$$

EPA uses this to compare CO_2 emissions from other sources to emissions from passenger vehicles. For example, an energy efficiency program that reduces greenhouse gas emissions by 5,100 metric tons of CO_2 per year has the same impact as removing 1000 vehicles from the road.

Are there other sources of greenhouse gas emissions from a vehicle?

In addition to carbon dioxide (CO_2), automobiles produce methane (CH_4) and nitrous oxide (N_2O) from the tailpipe, as well as hydro fluorocarbon (HFC) emissions from leaking air conditioners. The emissions of these gases are small in comparison to CO_2; however, these gases are more potent greenhouse gases (they have a higher global warming potential) than CO_2.

[3] This is representative of the light duty passenger vehicle fleet as a whole, including both new and existing vehicles. EPA expects the average passenger vehicle fuel economy to increase over time as a result of new greenhouse gas and fuel economy standards developed in coordination between EPA, DOT and California.

[4] This calculation provides a simple way to determine the average annual CO_2 emissions from a passenger vehicle. Anyone that needs a more detailed approach should use the EPA's Motor Vehicle Emission Simulator (MOVES) model (www.epa.gov/otaq/models/moves/index.htm). This model contains detailed data about the light duty fleet and driving patterns in the United States. Although simplified, the calculated annual CO_2 emissions above are consistent with analyses performed by the EPA using MOVES.

Emissions of greenhouse gases are typically expressed in a common metric so that their impacts can be directly compared. The international standard is to express greenhouse gases in units of carbon dioxide equivalent, commonly written as CO_2e. For a given amount of a greenhouse gas, multiplying the amount of gas times the global warming potential (GWP) for that gas results in the amount of greenhouse gas in terms of CO_2e. For automotive-related gases, these global warming potentials are:

Greenhouse Gas	Abbreviation	GWP[5]
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298
Air Conditioning Refrigerant	HFC-134a	1,430

It is more difficult to estimate vehicle emissions of CH_4, N_2O, and HFCs than of CO_2. Emissions of CH_4 and N_2O are dependent on vehicle miles traveled rather than fuel consumption per mile. The amount of HFC leakage from air conditioners is dependent on many factors, including system design, amount of use, and maintenance. On average, CO_2 emissions represent 95-99% of the total greenhouse gas emissions from a passenger vehicle. CH_4, N_2O, and HFC emissions represent roughly 1-5% of the total greenhouse gas emissions from passenger vehicles, after accounting for the global warming potential of each greenhouse gas.

What are the tailpipe emissions from a plug-in hybrid or an electric vehicle? What about hydrogen fuel cell vehicles?

A vehicle that can only operate on electricity will not emit any tailpipe emissions. A fuel cell vehicle operating on hydrogen will emit only water vapor.

Plug-in hybrid vehicles (PHEVs) can operate on either electricity or gasoline. When a PHEV is operating on electricity, it does not create any tailpipe emissions. However, when it is operating on gasoline, it creates tailpipe greenhouse gas emissions based on the PHEV's gasoline fuel economy. These emissions can be calculated as shown in the second question. The overall tailpipe emissions for a PHEV depend on the percentage of miles the vehicle drives on electricity versus gasoline. This can vary significantly based on the PHEV's battery capacity, how it is driven, and how often it is charged.

Are there any greenhouse gas emissions associated with the use of my vehicle other than the tailpipe emissions?

Driving most vehicles creates tailpipe greenhouse gas emissions. Producing and distributing the fuel used to power your vehicle also creates greenhouse gasses. Gasoline, for example, requires

[5] These 100-year time horizon GWP values are from the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

extracting oil from the ground, transporting it to a refinery, refining the oil into gasoline, and transporting the gasoline to service stations. Each of these steps can produce additional greenhouse gas emissions.

Electric vehicles have no tailpipe emissions; however, greenhouse gas emissions are created during both the production and distribution of the electricity used to fuel the vehicle. Calculators on Fueleconomy.gov allow you to estimate grams of greenhouse gas emissions per mile for an electric vehicle in your region of the country.

I thought my gasoline was blended with ethanol. Does that change the tailpipe CO_2 emissions?

It is common in the U.S. to blend gasoline with a small percentage of ethanol. Most of the gasoline sold in the U.S.is really a mixture of gasoline and up to 10% ethanol (this mixture is often referred to as E10)[6]. The exact formulation of the gasoline in your vehicle will vary depending on season, region in the U.S., and other factors. While your fuel economy when using an ethanol blend in your vehicle will be slightly lower than when using pure gasoline, the CO_2 tailpipe emissions per mile will be similar. This is because ethanol has less carbon per gallon than gasoline.

How does the EPA measure CO_2 emissions from motor vehicles?

The EPA and automobile manufacturers test vehicles using a set of standardized laboratory tests. These tests were designed by the EPA to mimic typical driving patterns. The EPA and the Department of Transportation use these values to ensure that the vehicle meets federal corporate average fuel economy (CAFE) standards. The test results are then adjusted to reflect different driving conditions and estimate fuel economy and greenhouse gas emissions for an average driver. These adjusted results are used on the Fuel Economy and Environment Label seen on all new vehicles and on Fueleconomy.gov. Detailed information on the test cycles is available on the EPA's National Vehicle and Fuel Emissions Laboratory website (www.epa.gov/nvfel/).

How can I find and compare CO_2 emission rates for specific vehicle models?

You can find and compare vehicle CO_2 emissions at Fueleconomy.gov. Beginning with model year 2013, vehicle manufacturers will include tailpipe CO_2 emission rates on the vehicle Fuel Economy and Environment labels. These new labels also feature a convenient 1-to 10 Fuel Economy and Greenhouse Gas Rating to enable easy comparison shopping. A Smartphone QR Code ® on the label will direct consumers to the website Fueleconomy.gov for more information.[7]

[6] The amount of ethanol in gasoline has historically been limited to 10%; however, the E15 waiver increases that amount to 15% for some vehicles. For more information see: www.epa.gov/otaq/regs/fuels/additive/e15/

[7] QR (or "quick response") Codes are simply two-dimensional bar codes used to store information. In this case, the information is a web site URL. The term QR Code ® is a registered trademark of Denso Wavve Incorporated.

The EPA publishes additional data in the report "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends" (www.epa.gov/otaq/fetrends.htm). The Trends Report analyzes trends in fuel economy and CO_2 emissions for new light duty vehicles from 1975 to the present.

Where can I find information on the emissions of the transportation sector as a whole? How can I compare this to other sectors?

You can find documents on greenhouse gas emissions on the EPA's Transportation and Climate (www.epa.gov/otaq/climate) website. This website is maintained by the Office of Transportation and Air Quality (OTAQ).

- U.S. Greenhouse Gas Inventory Report (EPA-430-R-11-005, April 2011): www.epa.gov/climatechange/emissions/usinventoryreport.html
- Light-Duty Greenhouse Gas Standards: www.epa.gov/otaq/climate/regulations.htm
- Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: www.epa.gov/otaq/fetrends.htm
- Fueleconomy.gov

For additional information on calculating emissions of greenhouse gases, please contact:

OTAQ@epa.gov

Or you can contact the OTAQ library for document information at:

U. S. Environmental Protection Agency
Office of Transportation and Air Quality
2000 Traverwood Drive
Ann Arbor, MI 48105
734-214-4311 & 734-214-4434
E-mail: Group_AAlibrary@epa.gov

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Exhibit 3

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Contents lists available at SciVerse ScienceDirect

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The carbon footprint of indoor *Cannabis* production

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ABSTRACT

The emergent industry of indoor *Cannabis* production – legal in some jurisdictions and illicit in others – utilizes highly energy intensive processes to control environmental conditions during cultivation. This article estimates the energy consumption for this practice in the United States at 1% of national electricity use, or $6 billion each year. One average kilogram of final product is associated with 4600 kg of carbon dioxide emissions to the atmosphere, or that of 3 million average U.S. cars when aggregated across all national production. The practice of indoor cultivation is driven by criminalization, pursuit of security, pest and disease management, and the desire for greater process control and yields. Energy analysts and policymakers have not previously addressed this use of energy. The unchecked growth of electricity demand in this sector confounds energy forecasts and obscures savings from energy efficiency programs and policies. While criminalization has contributed to the substantial energy intensity, legalization would not change the situation materially without ancillary efforts to manage energy use, provide consumer information via labeling, and other measures. Were product prices to fall as a result of legalization, indoor production using current practices could rapidly become non-viable.

1. Introduction

On occasion, previously unrecognized spheres of energy use come to light. Important historical examples include the pervasive air leakage from ductwork in homes, the bourgeoning energy intensity of computer datacenters, and the electricity "leaking" from billions of small power supplies and other equipment. Intensive periods of investigation, technology R&D, and policy development gradually ensue in the wake of these discoveries. The emergent industry of indoor *Cannabis* production appears to have joined this list.[1]

This article presents a model of the modern-day production process – based on public-domain sources – and provides first-order national scoping estimates of the energy use, costs, and greenhouse-gas emissions associated with this activity in the United States. The practice is common in other countries but a global assessment is beyond the scope of this report.

2. Scale of activity

The large-scale industrialized and highly energy-intensive indoor cultivation of *Cannabis* is a relatively new phenomenon, driven by criminalization, pursuit of security, pest and disease management, and the desire for greater process control and yields (U.S. Department of Justice, 2011a; World Drug Report, 2009). The practice occurs across the United States (Hudson, 2003; Gettman, 2006). The 415,000 indoor plants eradicated by authorities in 2009 (and 10.3 million including outdoor plantations) (U.S. Department of Justice, 2011a, b) presumably represent only a small fraction of total production.

Cannabis cultivation is today legal in 15 states plus the District of Columbia, although it is not federally sanctioned (Peplow, 2005). It is estimated that 24.8 million Americans are eligible to receive a doctor's recommendation to purchase or cultivate *Cannabis* under existing state laws, and approximately 730,000 currently do so (See Change Strategy, 2011). In California alone, 400,000 individuals are currently authorized to cultivate *Cannabis* for personal medical use, or sale for the same purpose to 2100 dispensaries (Harvey, 2009). Approximately 28.5 million people in the United States are repeat consumers, representing 11% of the population over the age of 12 (U.S. Office of National Drug Control Policy, 2011).

Cultivation is also substantial in Canada. An estimated 17,500 "grow" operations in British Columbia (typically located in residential buildings) are equivalent to 1% of all dwelling units Province-wide, with an annual market value of $7 billion (Easton, 2004).

Official estimates of total U.S. *Cannabis* production varied from 10,000 to 24,000 metric ton per year as of 2001, making it the nation's largest crop by value at that time (Hudson, 2003; Gettman, 2006). A recent study estimated national production at far higher levels (69,000 metric ton) (HIDTA, 2010). Even at the

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[1] This article substantively updates and extends the analysis described in Mills (2011).

0301-4215/$ - see front matter
http://dx.doi.org/10.1016/j.enpol.2012.03.023

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lower end of this range (chosen as the basis of this analysis), the level of activity is formidable and increasing with the demand for *Cannabis*.

No systematic efforts have previously been made to estimate the aggregate energy use of these activities.

3. Methods and uncertainties

This analysis is based on a model of typical *Cannabis* production, and the associated energy use for cultivation and transportation based on market data and first-principals buildings energy end-use modeling techniques. Data sources include equipment manufacturer data, trade media, the open literature, and interviews with horticultural equipment vendors. All assumptions used in the analysis are presented in Appendix A. The resulting normalized (per-kilogram) energy intensity is driven by the effects of indoor-environmental conditions, production processes, and equipment efficiencies.

Considerable energy use is also associated with transportation, both for workers and for large numbers of small-quantities transported and then redistributed over long distances before final sale.

This analysis reflects typical practices, and is thus intended as a "central estimate". While processes that use less energy on a per-unit-yield basis are possible, much more energy-intensive scenarios also occur. Certain strategies for lowering energy inputs (e.g., reduced illumination levels) can result in lower yields, and thus not necessarily reduce the ultimate energy-intensity per unit weight. Only those strategies that improve equipment and process energy efficiency, while not correspondingly attenuating yields would reduce energy intensity.

Due to the proprietary and often illicit nature of Cannabis cultivation, data are intrinsically uncertain. Key uncertainties are total production and the indoor fraction thereof, and the corresponding scaling up of relatively well-understood intensities of energy use per unit of production to state or national levels could result in 50% higher or lower aggregate results. Greenhouse-gas emissions estimates are in turn sensitive to the assumed mix of on- and off-grid power production technologies and fuels, as off-grid production (almost universally done with diesel generators) can – depending on the prevailing fuel mix in the grid – have substantially higher emissions per kilowatt-hour than grid power. Final energy costs are a direct function of the aforementioned factors, combined with electricity tariffs, which vary widely geographically and among customer classes. The assumptions about vehicle energy use are likely conservative, given the longer-range transportation associated with interstate distribution.

Some localities (very cold and very hot climates) will see much larger shares of production indoors, and have higher space-conditioning energy demands than the typical conditions assumed here. More in-depth analyses could explore the variations introduced by geography and climate, alternate technology configurations, and production techniques.

4. Energy implications

Accelerated electricity demand growth has been observed in areas reputed to have extensive indoor *Cannabis* cultivation. For example, following the legalization of cultivation for medical purposes (Phillips, 1998; Roth, 2005; Clapper et al., 2010) in California in 1996, Humboldt County experienced a 50% rise in per-capita residential electricity use compared to other parts of the state (Lehman and Johnstone, 2010).

Aside from sporadic news reports (Anderson, 2010; Quinones, 2010), policymakers and consumers possess little information on the energy implications of this practice. A few prior studies tangentially mentioning energy use associated with *Cannabis* production used cursory methods and under-estimate energy use significantly (Plecas et al., 2010 and Caulkins, 2010).

Driving the large energy requirements of indoor production facilities are lighting levels matching those found in hospital operating rooms (500-times greater than recommended for reading) and 30 hourly air changes (6-times the rate in high-tech laboratories, and 60-times the rate in a modern home). Resulting power densities are on the order of 2000 W/m^2, which is on a par with that of modern datacenters. Indoor carbon dioxide (CO_2) levels are often raised to 4-times natural levels in order to boost plant growth. However, by shortening the growth cycle, this practice may reduce final energy intensity.

Specific energy uses include high-intensity lighting, dehumidification to remove water vapor and avoid mold formation, space heating or cooling during non-illuminated periods and drying, pre-heating of irrigation water, generation of carbon dioxide by burning fossil fuel, and ventilation and air-conditioning to remove waste heat. Substantial energy inefficiencies arise from air cleaning, noise and odor suppression, and inefficient electric generators used to avoid conspicuous utility bills. So-called "grow houses" – residential buildings converted for *Cannabis* production – can contain 50,000 to 100,000 W of installed lighting power (Brady, 2004). Much larger facilities are also used.

Based on the model developed in this article, approximately 13,000 kW/h/year of electricity is required to operate a standard production module (a 1.2 × 1.2 × 2.4 m (4 × 4 × 8 ft) chamber). Each module yields approximately 0.5 kg (1 pound) of final product per cycle, with four or five production cycles conducted per year. A single grow house can contain 10 to 100 such modules.

To estimate national electricity use, these normalized values are applied to the lower end of the range of the aforementioned estimated production (10,000 t per year), with one-third of the activity takes place under indoor conditions. This indicates electricity use of about 20 TW/h/year nationally (including off-grid production). This is equivalent to that of 2 million average U.S. homes, corresponding to approximately 1% of national electricity consumption — or the output of 7 large electric power plants (Koomey et al., 2010). This energy, plus associated fuel uses (discussed below), is valued at $6 billion annually, with associated emissions of 15 million metric ton of CO_2 — equivalent to that of 3 million average American cars (Fig. 1 and Tables 1–3.)

Fuel is used for several purposes, in addition to electricity. The carbon dioxide injected into grow rooms to increase yields is produced industrially (Overcash et al., 2007) or by burning propane or natural gas within the grow room contributes about 1–2% to the carbon footprint and represents a yearly U.S. expenditure of $0.1 billion. Vehicle use associated with production and distribution contributes about 15% of total emissions, and represents a yearly expenditure of $1 billion. Off-grid diesel- and gasoline-fueled electric generators have per-kilowatt-hour emissions burdens that are 3- and 4-times those of average grid electricity in California. It requires 70 gallon of diesel fuel to produce one indoor *Cannabis* plant (or the equivalent yield per unit area), or 140 gallon with smaller, less-efficient gasoline generators.

In California, the top-producing state, indoor cultivation is responsible for about 3% of all electricity use, or 9% of household use.[2] This corresponds to the electricity use of 1 million average California homes, greenhouse-gas emissions equal to those from 1 million average cars, and energy expenditures of $3 billion per

[2] This is somewhat higher than estimates previously made for British Columbia, specifically, 2% of total Provincial electricity use or 6% of residential use (Garis, 2008; Bellett, 2010).

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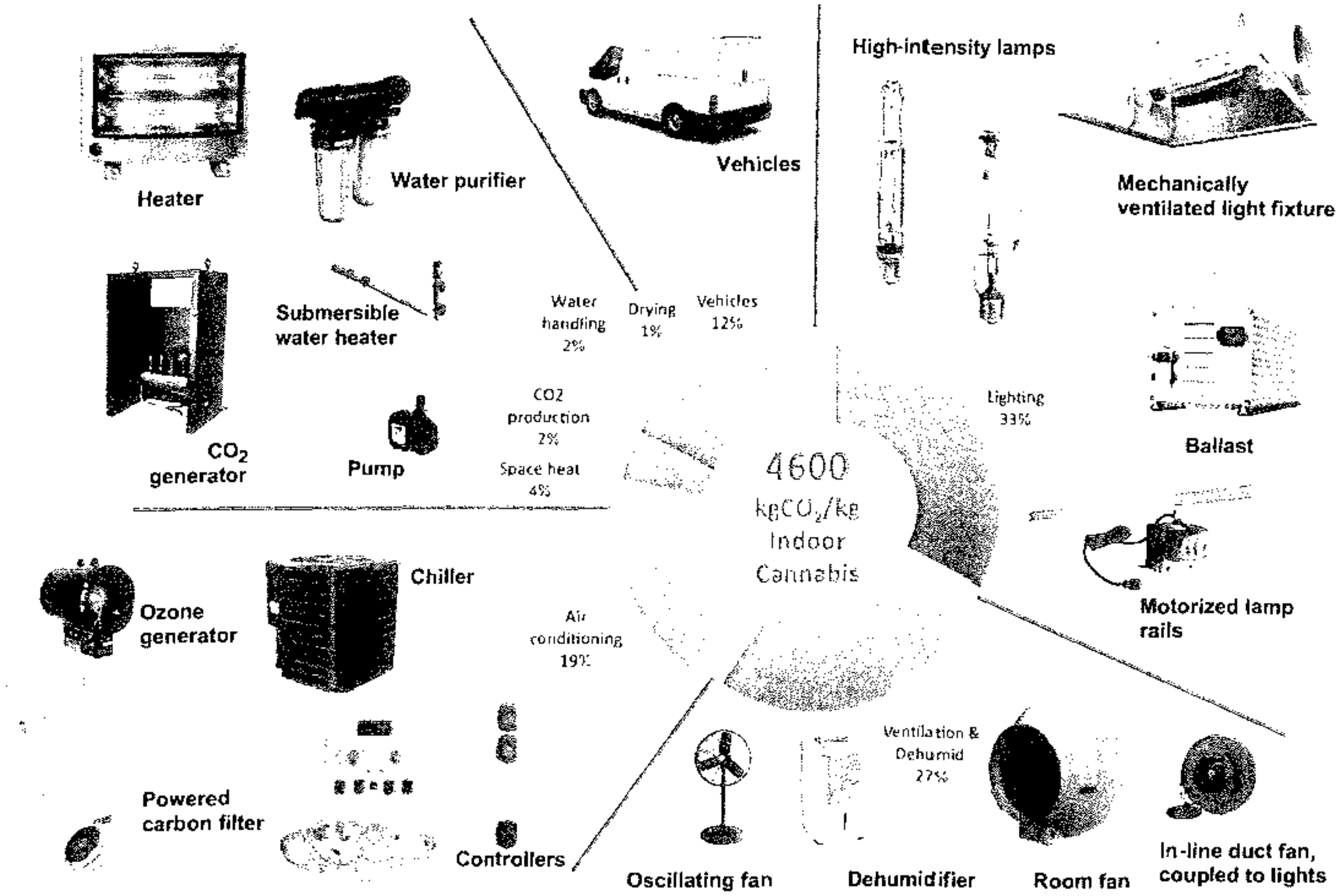

Fig. 1. Carbon footprint of indoor Cannabis production.

Table 1
Carbon footprint of indoor *Cannabis* production, by end use (average U.S conditions).

	Energy intensity (kW/h/kg yield)	Emissions factor ($kgCO_2$ emissions/kg yield)	
Lighting	2283	1520	33%
Ventilation & dehumid.	1848	1231	27%
Air conditioning	1284	855	19%
Space heat	304	202	4%
CO_2 injected to increase foliage	93	82	2%
Water handling	173	115	2%
Drying	90	60	1%
Vehicles		546	12%
Total	6074	4612	100%

Note: The calculations are based on U.S.-average carbon burdens of 0.666 kg/kW/h. "CO_2 injected to increase foliage" represents combustion fuel to make on-site CO_2. Assumes 15% of electricity is produced in off-grid generators.

year. Due to higher electricity prices and cleaner fuels used to make electricity, California incurs 50% of national energy costs but contributes only 25% of national CO_2 emissions from indoor *Cannabis* cultivation.

From the perspective of individual consumers, a single *Cannabis* cigarette represents 1.5 kg (3 pounds) of CO_2 emissions, an amount equal to driving a 44 mpg hybrid car 22 mile or running a 100-watt light bulb for 25 h, assuming average U.S. electricity emissions. The electricity requirement for one single production module equals that of an average U.S. home and twice that of an average California home. The added electricity use is equivalent to running about 30 refrigerators.

From the perspective of a producer, the national-average annual energy costs are approximately $5500 per module or $2500 per kilogram of finished product. This can represent half the wholesale value of the finished product (and a substantially lower portion at retail), depending on local conditions. For average U.S. conditions, producing one kilogram of processed *Cannabis* results in 4600 kg of CO_2 emissions to the atmosphere (and 50% more when off-grid diesel power generation is used), a very significant carbon footprint. The emissions associated with one kilogram of processed *Cannabis* are equivalent to those of driving across country 11 times in a 44-mpg car.

These results reflect typical production methods. Much more energy-intensive methods occur, e.g., rooms using 100% recirculated air with simultaneous heating and cooling, hydroponics, or energy end uses not counted here such as well-water pumps and water purification systems. Minimal information and consideration of energy use, coupled with adaptations for security and privacy (off-grid generation, no daylighting, odor and noise control) lead to particularly inefficient configurations and correspondingly elevated energy use and greenhouse-gas emissions.

The embodied energy of inputs such as soil, fertilizer, water, equipment, building materials, refinement, and retailing is not estimated here and should be considered in future assessments. The energy use for producing outdoor-grown *Cannabis* (approximately two-thirds of all production) is also not estimated here.

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Table 2
Equivalencies.

Indoor Cannabis production consumes…	3%	of California's total electricity, and	9%	of California's household electricity	1%	of total U.S. electricity, and	2% of U.S. household electricity
U.S. Cannabis production & distribution energy costs…	$ 6	Billion, and results in the emissions of	15	Million tonnes per year of greenhouse gas emissions (CO_2)	Equal to the emissions of	3	million average cars
U.S. electricity use for Cannabis production is equivalent to that of…	1.7	Million average U.S. homes	or	7	Average U.S. power plants		
California Cannabis production and distribution energy costs...	$ 3	Billion, and results in the emissions of	4	Million tonnes per year of greenhouse gas emissions (CO_2)	Equal to the emissions of	1	Million average cars
California electricity use for Cannabis production is equivalent to that of…	1	Million average California homes					
A typical 4 × 4 × 8-ft production module, accomodating four plants at a time, consumes as much electricity as..	1	Average U.S. homes, or	2	Average California homes	or	29	Average new refrigerators
Every 1 kilogram of Cannabis produced using national-average grid power results in the emissions of…	4.3	Tonnes of CO_2	Equiva-lent to	7	Cross-country trips in a 5.3 l/100 km (44 mp g) car		
Every 1 kg of Cannabis produced using a prorated mix of grid and off-grid generators results in the emissions of…	4.6	Tonnes of CO_2	Equiva-lent to	8	Cross-country trips in a 5.3 l/100 km (44 mp g) car		
Every 1 kg of Cannabis produced using off-grid generators results in the emissions of…	6.6	Tonnes of CO_2	Equiva-lent to	11	Cross-country trips in a 5.3 l/100 km (44 mp g) car		
Transportation (wholesale + retail) consumes…	226	Liters of gasoline per kg	or	$ 1	Billion dollars annually, and	546	Kilograms of CO_2 per kilogram of final product
One Cannabis cigarette is like driving…	37	km in a 5.3 l/100 km (44 mpg) car	Emitting about	2	kg of CO_2, which is equivalent to operating a 100-watt light bulb for	25	Hours
Of the total wholesale price…	49%	Is for energy (at average U.S. prices)					

If improved practices applicable to commercial agricultural greenhouses are any indication, such large amounts of energy are not required for indoor *Cannabis* production.[3] The application of cost-effective, commercially-available efficiency improvements to the prototypical facility modeled in this article could reduce energy intensities by at least 75% compared to the typical-efficiency baseline. Such savings would be valued at approximately $40,000/year for a generic 10-module operation (at California energy prices and $10,000/year at U.S. average prices) (Fig. 2(a)–(b). These estimated energy use reductions reflect practices that are commonplace in other contexts such as more efficient components and controls (lights, fans, space-conditioning), use of daylight, optimized air-handling systems, and relocation of heat-producing equipment out of the cultivation room. Moreover, strain choice alone results in a factor-of-two difference in yields per unit of energy input (Arnold, 2011).

[3] See, e.g., this University of Michigan resource: http://www.hrt.msu.edu/energy/Default.htm

5. Energy intensities in context

Policymakers and other interested parties will rightfully seek to put these energy indicators in context with other activities in the economy.

One can readily identify other energy end-use activities with far greater impacts than that of *Cannabis* production. For example, automobiles are responsible for about 33% of U.S. greenhouse-gas emissions (USDOE, 2009), which is100-times as much as those produced by indoor *Cannabis* production (0.3%). The approximately 20 TW/h/year estimated for indoor *Cannabis* production is about one/third that of U.S. data centers (US EPA, 2007a, 2007b), or one-seventh that of U.S. household refrigerators (USDOE, 2008). These shares would be much higher in states where *Cannabis* cultivation is concentrated (e.g., one half that of refrigerators in California (Brown and Koomey, 2002)).

On the other hand, this level of energy use is high in comparison to that used for other indoor cultivation practices, primarily owing to the lack of daylighting. For comparison, the energy intensity of Belgian greenhouses is estimated at approximately 1000 MJ/m^2 (De Cock and Van Lierde, No date), or about 1% that estimated here for indoor *Cannabis* production.

Table 3
Energy indicators (average U.S. conditions).

	per cycle, per production module	per year, per production module	
Energy use			
Connected load		3,225	(watts/module)
Power density		2,169	(watts/m^2)
Elect	2756	12,898	(kW/h/module)
Fuel to make CO_2	0.3	1.6	(GJ)
Transportation fuel	27	127	(Gallons
On-grid results			
Energy cost	846	3,961	$/module
Energy cost		1,866	$/kg
Fraction of wholesale price		47%	
CO_2 emissions	1936	9,058	kg
CO_2 emissions		4,267	kg/kg
Off-grid results (diesel)			
Energy cost	1183	5,536	$/module
Energy cost		2,608	$/kg
Fraction of wholesale price		65%	
CO_2 emissions	2982	13,953	kg
CO_2 emissions		6,574	kgCO_2/kg
Blended on/off grid results			
Energy cost	897	4,197	$/module
Energy cost		1,977	$/kg
Fraction of wholesale price		49%	
CO_2 emissions	2093	9,792	kg
CO_2 emissions		4,613	kgCO_2/kg
Of which, indoor CO_2 production	9	42	kgCO_2
Of which, vehicle use			
Fuel use			
During production		79	Liters/kg
Distribution		147	Liters/kg
Cost			
During production		77	$/kg
Distribution		143	$/kg
Emissions			
During production		191	kgCO_2/kg
Distribution		355	kgCO_2/kg

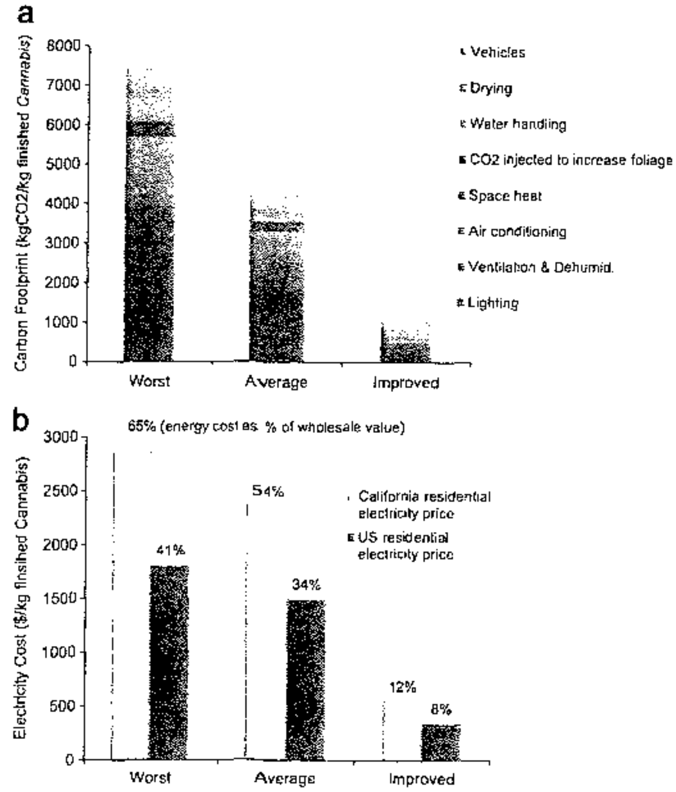

Fig. 2. Carbon footprint and energy cost for three levels of efficiency. (a) Indoor cannabis: carbon footprint. (b) Indoor cannabis: electricity cost. Assumes a wholesale price of $4400/kg. Wholesale prices are highly variable and poorly documented.

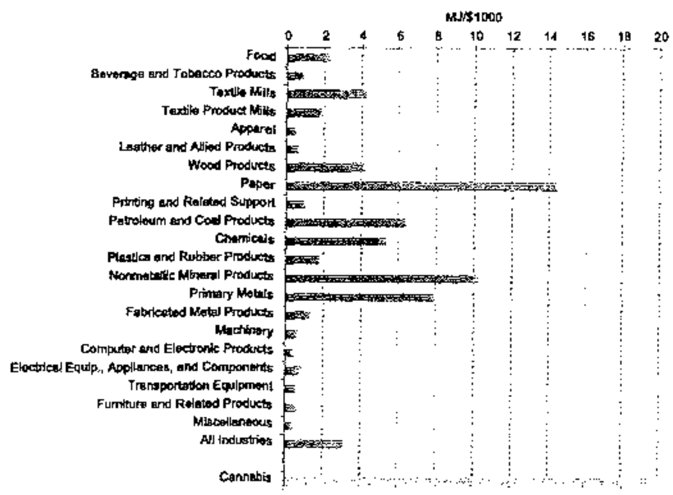

Fig. 3. Comparative energy intensities, by sector (2006).

Energy intensities can also be compared to those of other sectors and activities.

- Pharmaceuticals — Energy represents 1% of the value of U.S. pharmaceutical shipments (Galitsky et al., 2008) versus 50% of the value of Cannabis wholesale prices. The U.S. "Pharma" sector uses $1 billion/year of energy; Indoor Cannabis uses $6 billion.
- Other industries — Defining "efficiency" as how much energy is required to generate economic value, Cannabis comes out the highest of all 21 industries (measured at the three-digit SIC level). At ~20 MJ per thousand dollars of shipment value (wholesale price), Cannabis is followed next by paper (~14), nonmetallic mineral products (~10), primary metals (~8), petroleum and coal products (~6), and then chemicals (~5) (Fig. 3). However, energy intensities are on a par with *Cannabis* in various subsectors (e.g., grain milling, wood products, rubber) and exceed those of *Cannabis* in others (e.g., pulp mills).
- Alcohol — The energy used to produce one marijuana cigarette would also produce 18 pints of beer (Galitsky et al., 2003).
- Other building types — Cannabis production requires 8-times as much energy per square foot as a typical U.S. commercial building (4x that of a hospital and 20x that of a building for religious worship), and 18-times that of an average U.S. home (Fig. 4).

6. Outdoor cultivation

Shifting cultivation outdoors can nearly eliminate energy use for the cultivation process. Many such operations, however, require water pumping as well as energy-assisted drying techniques. Moreover, vehicle transport during production and distribution remains part of the process, more so than for indoor operations.

A common perception is that the potency of *Cannabis* produced indoors exceeds that of that produced outdoors, leading

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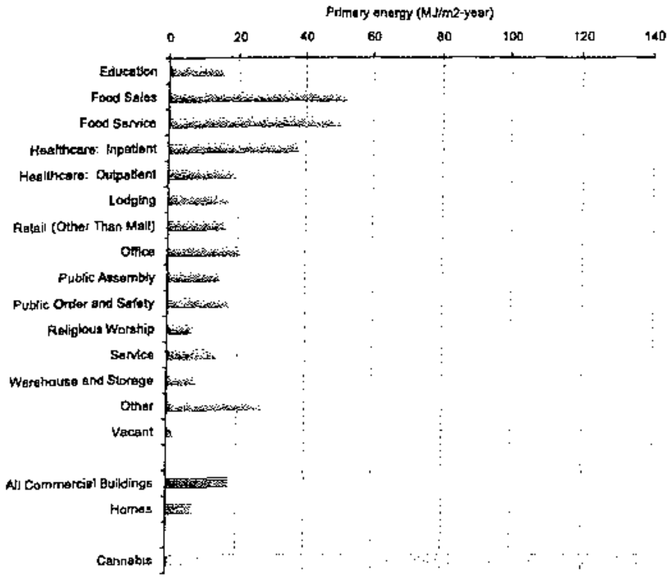

Fig. 4. Comparative energy intensities, by U.S. building type (2003).

consumers to demand *Cannabis* produced indoors. Federal sources (National Drug Intelligence Center, 2005) as well as independent testing laboratories (Kovner, 2011) actually find similar potencies when best practices are used.

Illegal clearing of land is common for multi-acre plantations, and, depending on the vegetation type, can accordingly mobilize greenhouse-gas emissions. Standing forests (a worst-case scenario) hold from 125 to 1500 t of CO_2 per hectare, depending on tree species, age, and location (National Council for Air and Soil Improvement, 2010). For biomass carbon inventories of 750 t/ha and typical yields (5000 kg/ha) (UNODC, 2009), associated biomass-related CO_2 emissions would be on the order of 150 kg CO_2/kg *Cannabis* (for only one harvest per location), or 3% of that associated with indoor production. These sites typically host on the order of 10,000 plants, although the number can go much higher (Mallery, 2011). When mismanaged, the practice of outdoor cultivation imposes multiple environmental impacts aside from energy use. These include deforestation; destruction of wetlands, runoff of soil, pesticides, insecticides, rodenticides, and human waste; abandoned solid waste; and unpermitted impounding and withdrawals of surface water (Mallery, 2011; Revelle, 2009). These practices can compromise water quality, fisheries, and other ecosystem services.

7. Policy considerations

Current indoor *Cannabis* production and distribution practices result in prodigious energy use, costs, and unchecked greenhouse-gas pollution. While various uncertainties exist in the analysis, the overarching qualitative conclusions are robust. More in-depth analysis and greater transparency of the energy impacts of this practice could improve decision-making by policymakers and consumers alike.

There is little, if any, indication that public policymakers have incorporated energy and environmental considerations into their deliberations on *Cannabis* production and use. There are additional adverse impacts of the practice that merit attention, including elevated moisture levels associated with indoor cultivation that can cause extensive damage to buildings,[4] as well as electrical fires caused by wiring out of compliance with safety codes (Garis, 2008). Power theft is common, transferring those energy costs to the general public (Plecas et al., 2010). As noted above, simply shifting production outdoors can invoke new environmental impacts if not done properly.

Energy analysts have also not previously addressed the issue. Aside from the attention that any energy use of this magnitude normally receives, the hidden growth of electricity demand in this sector confounds energy forecasts and obscures savings from energy efficiency programs and policies. For example, Auffhammer and Aroonruengsawat (2010) identified a

[4] For observations from the building inspectors community, see http://www.nachi.org/marijuana-grow-operations.htm

Table A1
Configuration, environmental conditions, set-points.

Production parameters		
Growing module	1.5	m^2 (excl. walking area)
Number of modules in a room	10	
Area of room	22	m^2
Cycle duration	78	days
Production continuous throughout the year	4.7	cycles
Illumination	Leaf phase	Flowering phase
Illuminance	25 klux	100 klux
Lamp type	Metal halide	High-pressure sodium
Watts/lamp	600	1000
Ballast losses (mix of magnetic & digital)	13%	0.13
Lamps per growing module	1	1
Hours/day	18	12
Days/cycle	18	60
Daylighting	None	none
Ventilation		
Ducted luminaires with "sealed" lighting compartment	150	CFM/1000 W of light (free flow)
Room ventilation (supply and exhaust fans)	30	ACH
Filtration	Charcoal filters on exhaust; HEPA on supply	
Oscilating fans: per module, while lights on	1	
Water		
Application	151	liters/room-day
Heating	Electric submersible heaters	
Space conditioning		
Indoor setpoint — day	28	C
Indoor setpoint — night	20	C
AC efficiency	10	SEER
Dehumidification	7x24	hours
CO_2 production — target concentration (mostly natural gas combustion in space)	1500	ppm
Electric space heating	When lights off to maintain indoor setpoint	
Target indoor humidity conditions	40–50%	
Fraction of lighting system heat production removed by luminaire ventilation	30%	
Ballast location	Inside conditioned space	
Drying		
Space conditioning, oscillating fans, maintaining 50% RH, 70–80F	7	Days
Electricity supply		
grid	85%	
grid-independent generation (mix of diesel, propane, and gasoline)	15%	

Table A2
Assumptions and conversion factors.

Service levels		
Illuminance*	25–100	1000 lux
Airchange rates*	30	Changes per hour
Operations		
Cycle duration**	78	Days
Cycles/year**	4.7	Continuous production
Airflow**	96	Cubic feet per minute, per module
Lighting		
Leafing phase		
Lighting on-time*	18	hrs/day
Duration*	18	days/cycle
Flowering phase		
Lighting on-time*	12	hrs/day
Duration*	60	days/cycle
Drying		
Hours/day*	24	hrs
Duration*	7	days/cycle
Equipment		
Average air-conditioning age	5	Years
Air conditioner efficiency [Standards increased to SEER 13 on 1/23/2006]	10	SEER
Fraction of lighting system heat production removed by luminaire ventilation	0.3	
Diesel generator efficiency*	27%	55 kW
Propane generator efficiency*	25%	27 kW
Gasoline generator efficiency*	15%	5.5 kW
Fraction of total prod'n with generators*	15%	
Transportation: Production phase (10 modules)	25	Miles roundtrip
Daily service (1 vehicle)	78	Trips/cycle. Assume 20% live on site
Biweekly service (2 vehicles)	11.1	Trips/cycle
Harvest (2 vehicles)	10	Trips/cycle
Total vehicle miles**	2089	Vehicle miles/cycle
Transportation: Distribution		
Amount transported wholesale	5	kg per trip
Mileage (roundtrip)	1208	km/cycle
Retail (0.25oz × 5 miles roundtrip)	5668	Vehicle-km/cycle
Total**	6876	Vehicle-km/cycle
Fuel economy, typical car [a]	10.7	l/100 km
Annual emissions, typical car [a]	5195	$kgCO_2$
	0	$kgCO_2$/mile
Annual emissions, 44-mpg car**	2,598	$kgCO_2$
	0.208	$kgCO_2$/mile
Cross-country U.S. mileage	4493	km
Fuels		
Propane [b]	25	MJ/liter
Diesel [b]	38	MJ/liter
Gasoline [b]	34	MJ/liter
Electric generation mix*		
Grid	85%	share
Diesel generators	8%	share
Propane generators	5%	share
Gasoline generators	2%	share
Emissions factors		
Grid electricity — U.S. [c]	0.609	$kgCO_2$/kW/h
Grid electricity — CA [c]	0.384	$kgCO_2$/kW/h
Grid electricity — non-CA U.S. [c]	0.648	$kgCO_2$/kW/h
Diesel generator**	0.922	$kgCO_2$/kW/h
Propane generator**	0.877	$kgCO_2$/kW/h
Gasoline generator**	1.533	$kgCO_2$/kW/h
Blended generator mix**	0.989	$kgCO_2$/kW/h
Blended on/off-grid generation — CA**	0.475	$kgCO_2$/kW/h
Blended on/off-grid generation — U.S.**	0.666	$kgCO_2$/kW/h
Propane combustion	63.1	$kgCO_2$/MBTU
Prices		
Electricity price — grid (California — PG&E) [d]	0.390	per kW/h (Tier 5)
Electricity price — grid (U.S.) [e]	0.247	per kW/h
Electricity price — off-grid**	0.390	per kW/h
Electricity price — blended on/off — CA**	0.390	per kW/h
Electricity price — blended on/off — U.S.**	0.268	per kW/h
Propane price [f]	0.58	$/liter
Gasoline price — U.S. average [f]	0.97	$/liter
Diesel price — U.S. average [f]	1.05	$/liter

Table A2 (*continued*)

Wholesale price of Cannabis [g]	4,000	$/kg
Production		
Plants per production module*	4	
Net production per production module [h]	0.5	kg/cycle
U.S. production (2011) [i]	10,000	metric tonnes/y
California production (2011) [i]	3,902	metric tonnes/y
Fraction produced indoors [i]	33%	
U.S. indoor production modules**	1,570,399	
Calif indoor production modules**	612,741	
Cigarettes per kg**	3,000	
Other		
Average new U.S. refrigerator	450	kW/h/year
	173	$kgCO_2$/year (U.S. average)
Electricity use of a typical U.S. home — 2009 [j]	11,646	kW/h/year
Electricity use of a typical California home — 2009 [k]	6,961	kW/h/year

Notes:
* Trade and product literature; interviews with equipment vendors.
** Calculated from other values.
Notes for Table A2.
[a]. U.S. Environmental Protection Agency., 2011.
[b]. *Energy conversion factors*, U.S. Department of Energy, http://www.eia.doe.gov/energyexplained/index.cfm?page=about_energy_units, (Accessed February 5, 2011).
[c]. United States: (USDOE 2011); California (Marnay et al., 2002).
[d]. Average prices paid in California and other states with inverted-block tariffs are very high because virtually all consumption is in the most expensive tiers. Here the PG&E residential tariff as of 1/1/11, Tier 5 is used as a proxy for California http://www.pge.com/tariffs/ResElecCurrent.xls, (Accessed February 5, 2011). In practice a wide mix of tariffs apply, and in some states no tier structure is in place, or the proportionality of price to volume is nominal.
[e]. State-level residential prices, weighted by *Cannabis* production (from Gettman, 2006) with actual tariffs and U.S. Energy Information Administration, "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State", http://www.eia.doe.gov/electricity/epm/table5_6_a.html, (Accessed February 7, 2011)
[f]. U.S. Energy Information Administration, Gasoline and Diesel Fuel Update (as of 2/14/2011) – see http://www.eia.gov/oog/info/gdu/gasdiesel.asp Propane prices – http://www.eia.gov/dnav/pet/pet_pri_prop_a_EPLLPA_PTA_dpgal_m.htm, (Accessed April 3, 2011).
[g]. Montgomery, 2010.
[h]. Toonen et al., 2006); Plecas et al., 2010.
[i]. *Total Production*: The lower value of 10,000 t per year is conservatively retained. Were this base adjusted to 2011 values using 10.9%/year net increase in number of consumers between 2007 and 2009 per U.S. Department of Health and Human Services (2010), the result would be approximately 17 million tonnes of total production annually (indoor and outdoor). *Indoor Share of Total Production*: The three-fold changes in potency over the past two decades, reported by federal sources, are attributed at least in part to the shift towards indoor cultivation See http://www.justice.gov/ndic/pubs37/37035/national.htm and (Hudson, 2003). A weighted-average potency of 10% THC (U.S. Office of Drug Control Policy, 2010) reconciled with assumed 7.5% potency for outdoor production and 15% for indoor production implies 33.3%::67.7% indoor::outdoor production shares. For reference, as of 2008, 6% of eradicated plants were from indoor operations, which are more difficult to detect than outdoor operations. A 33% indoor share, combined with per-plant yields from Table 2, would correspond to a 4% eradication success rate for the levels reported (415,000 indoor plants eradicated in 2009) by the U.S. Drug Enforcement Agency (http://www.justice.gov/dea/programs/marijuana.htm). Assuming 400,000 members of medical Cannabis dispensaries in California (each of which is permitted to cultivate), and 50% of these producing in the generic 10-module room assumed in this analysis, output would slightly exceed this study's estimate of total statewide production. In practice, the vast majority of indoor production is no doubt conducted outside of the medical marijuana system.
[j]. Total U.S. electricity sales: U.S. energy information administration, "retail sales of electricity to ultimate customers: Total by end-use sector" http://www.eia.gov/cneaf/electricity/epm/table5_1.html, (Accessed March 5, 2011)
[k]. California Energy Commission, 2009; 2011.

statistically significant, but unexplained, increase in the growth rate for residential electricity in California during the years when indoor *Cannabis* production grew as an industry (since the mid-1990s).

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Table A3
Energy model.

ELECTRICITY	Energy type	Penetration	Rating (Watts or %)	Number of 4 × 4 × 8-ft production modules served	Input energy per module	Units	Hours/day (leaf phase)	Hours/day (flower phase)	Days/cycle (leaf phase)	Days/cycle (flower phase)	kW/h/cycle	kW/h/year per production module
Light												
Lamps (HPS)	elect	100%	1,000	1	1,000	W		12		60	720	3,369
Ballasts (losses)	elect	100%	13%	1	130	W		12		60	94	438
Lamps (MH)	elect	100%	600	1	600	W	18		18		194	910
Ballast (losses)	elect	100%	0	1	78	W	18		18		25	118
Motorized rail motion	elect	5%	6	1	0.3	W	18	12	18	60	0	1
Controllers	elect	50%	10	10	1	W	24	24	18	60	2	9
Ventilation and moisture control												
Luminare fans (sealed from conditioned space)	elect	100%	454	10	45	W	18	12	18	60	47	222
Main room fans — supply	elect	100%	242	8	30	W	18	12	18	60	31	145
Main room fans — exhaust	elect	100%	242	8	30	W	18	12	18	60	31	145
Circulating fans (18")	elect	100%	130	1	130	W	24	24	18	60	242	1,134
Dehumidification	elect	100%	1,035	4	259	W	24	24	18	60	484	2,267
Controllers	elect	50%	10	10	1	W	24	24	18	60	2	9
Spaceheat or cooling												
Resistance heat or AC [when lights off]		90%	1,850	10	167	W	6	12	18	60	138	645
Carbon dioxide injected to increase foliage												
Parasitic electricity	elect	50%	100	10	5	W	18	12	18	60	5	24
AC (see below)	elect	100%										
In-line heater	elect	5%	115	10	0.6	W	18	12	18	60	1	3
Dehumidification (10% adder)	elect	100%	104	0	26	W	18	12	18	60	27	126
Monitor/control	elect	100%	50	10	5	W	24	24	18	60	9	44
Other												
Irrigation water temperature control	elect	50%	300	10	15	W	18	12	18	60	19	89
Recirculating carbon filter [sealed room]	elect	20%	1,438	10	29	W	24	24	18	60	54	252
UV sterilization	Elect	90%	23	10	2.1	W	24	24	18	60	4	18
Irrigation pumping	elect	100%	100	10	10	W	2	2	18	60	2	7
Fumigation	elect	25%	20	10	1	W	24	24	18	60	1	4
Drying												
Dehumidification	elect	75%	1,035	10	78	W		24		7	13	61
Circulating fans	elect	100%	130	5	26	W		24		7	4	20
Heating	elect	75%	1,850	10	139	W		24		7	23	109
Electricity subtotal	elect										2,174	10,171
Air-conditioning				10	420	W					583	2,726
Lighting loads				10		W					259	1,212
Loads that can be remoted	elect	100%	1,277	10		W					239	1,119
Loads that can't be remoted	elect	100%	452	10		W					85	396
CO2-production heat removal	elect	45%	1,118	17		W	18	12	18	60	—	—
Electricity Total	elect				3,225	W					2,756	12,898

FUEL	Units	Technology Mix	Rating (BTU/h)	Number of 4 × 4 × 8-ft production modules served	Input energy per module		Hours/day (leaf phase)	Hours/day (flower phase)	Days/cycle (leaf phase)	Days/cycle (flower phase)	GJ or $kgCO_2$/cycle	GJ or $kgCO_2$/year
On-site CO_2 production												
Energy use	propane	45%	11,176	17	707	kJ/h	18	12	18	60	0.3	1.5
CO2 production - > emissions	kg/CO_2										20	93
Externally produced Industrial CO_2		5%		1	0.003	liters CO_2/hr	18	12	18	60	0.6	2.7
Weighted-average on-site/purchased	$kgCO_2$										2	10

For *Cannabis* producers, energy-related production costs have historically been acceptable given low energy prices and high product value. As energy prices have risen and wholesale commodity prices fallen, high energy costs (now 50% on average of wholesale value) are becoming untenable. Were product prices to fall as a result of legalization, indoor production could rapidly become unviable.

For legally sanctioned operations, the application of energy performance standards, efficiency incentives and education, coupled with the enforcement of appropriate construction codes could lay a foundation for public-private partnerships to reduce undesirable impacts of indoor *Cannabis* cultivation.[5] There are early indications of efforts to address this.[6] Were such operations to receive some form of independent certification and product labeling, environmental impacts could be made visible to otherwise unaware consumers.

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Two anonymous reviewers provided useful comments that improved the paper. Scott Zeramby offered particularly valuable insights into technology characteristics, equipment configurations, and market factors that influence energy utilization in this context and reviewed earlier drafts of the report.

Appendix A

See Tables A1–A3.

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Exhibit 4

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ENERGY UP IN SMOKE

THE CARBON FOOTPRINT OF INDOOR CANNABIS PRODUCTION

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April 5, 2011

* The research described in this report was conducted and published independently by the author, a long-time energy analyst and Staff Scientist at the Lawrence Berkeley National Laboratory, University of California. Scott Zeramby provided valuable insights into technology characteristics, equipment configurations, and market factors that influence energy utilization.

The report can be downloaded from: http://evan-mills.com/energy-associates/Indoor.html

On occasion, previously unrecognized spheres of energy use come to light. Important examples include the pervasive air leakage from ductwork in homes, the bourgeoning energy intensity of computer datacenters, and the electricity "leaking" from millions of small power supplies and other equipment. Intensive periods of investigation, technology R&D, and policy development gradually ensue in the wake of these discoveries.

The emergent industry of indoor Cannabis production appears to have joined the list. This report presents a model of the modern-day production process—based on public sources and equipment vendor data—and provides national scoping estimates of the energy use, costs, and greenhouse-gas emissions associated with this activity in the United States.[1]

Large-scale industrialized and highly energy-intensive indoor cultivation of Cannabis is a relatively new phenomenon, driven by criminalization, pursuit of security, and the desire for greater process control and yields.[2,3] The practice occurs in every state,[4] and the 415,000 indoor plants eradicated in 2009[5] represent only the tip of the iceberg.

Aside from sporadic news reports,[6,7] policymakers and consumers possess little information on the energy implications of this practice.[8] Substantially higher electricity demand growth is observed in areas reputed to have extensive indoor Cannabis cultivation. For example, following the legalization of cultivation for medical purposes in California in 1996, Humboldt County experienced a 50% rise in per-capita residential electricity use compared to other areas.[9] Cultivation is today legal in 17 states, albeit not federally sanctioned. In California, 400,000 individuals are authorized to grow Cannabis for personal medical use, or sale to 2,100 dispensaries.[10] Official estimates of total U.S. production varied from 10,000 to 24,000 metric tons per year in 2001,[4] making it the nation's largest crop by value.[11] As of 2006, one third of national indoor production was estimated to occur in California.[12] Based on a rising number of consumers (6.6% of U.S. population above the age of 12),[13] national production in 2011 is estimated for the purposes of this study at 17,000 metric tons, one-third occurring indoors.[14]

Driving the large energy requirements of indoor production facilities are lighting levels matching those found in hospital operating rooms (500-times greater than recommended for reading) and 30 hourly air changes (6-times the rate in high-tech laboratories, and 60-times the rate in a modern home). Resulting electricity intensities are 200 watts per square foot, which is on a par with modern datacenters. Indoor carbon dioxide (CO_2) levels are often raised to four-times natural levels in order to boost plant growth.

Specific energy uses include high-intensity lighting, dehumidification to remove water vapor, space heating during non-illuminated periods and drying, irrigation water pre-heating, generation of CO_2 by burning fossil fuel, and ventilation and air-conditioning to remove waste heat. Substantial energy inefficiencies arise from air cleaning, noise and odor suppression, and inefficient electric generators used to avoid conspicuous utility bills.

Based on these operational factors, the energy requirements to operate a standard production module—a 4x4x8 foot chamber—are approximately 13,000 kWh/year of electricity and 1.5×10^6 BTU/year of fossil fuel. A single grow house can contain 10 or more such modules. Power use scales to about 20 TWh/year nationally (including off-grid production and power theft), equivalent to that of 2 million average U.S. homes. This corresponds to 1% of national electricity consumption or 2% of that in households—or the output of 7 large electric power plants.[15] This energy, plus transportation fuel, is valued at $5 billion annually, with associated emissions of 17 million metric tons of CO_2—equivalent to that of 3 million average American cars. (See Figure 1 and Tables 1-5.)

Fuel is used for several purposes, in addition to electricity. Carbon dioxide, generated industrially[16] or by burning propane or natural gas, contributes about 2% to the carbon footprint. Vehicle use for production and distribution contributes about 15% of total emissions, and represents a yearly expenditure of $1 billion. Off-grid diesel- and gasoline-fueled electric generators have emissions burdens that are three- and four-times those of average grid electricity in California. It requires 70 gallons of diesel fuel to produce one indoor Cannabis plant, or 140 gallons with smaller, less-efficient gasoline generators.

In California, the top-producing state, indoor cultivation is responsible for about 3% of all electricity use or 8% of household use, somewhat higher than estimates previously made for British Columbia.[17] This corresponds to the electricity use of 1 million average California homes, greenhouse-gas emissions equal to those from 1 million average cars, and energy expenditures of $3 billion per year. Due to higher electricity prices and cleaner fuels used to make electricity, California incurs 70% of national energy costs but contributes only 20% of national CO_2 emissions from indoor Cannabis cultivation.

From the perspective of individual consumers, a single Cannabis cigarette represents 2 pounds of CO_2 emissions, an amount equal to running a 100-watt light bulb for 17 hours assuming average U.S. electricity emissions (or 30 hours on California's cleaner grid). The emissions associated with one kilogram of processed Cannabis are equivalent to those of driving across country 5 times in a 44-mpg car. One single production module doubles the electricity use of an average U.S. home and triples that of an average California home. The added electricity use is equivalent to running about 30 refrigerators. Producing one kilogram of processed Cannabis results in 3,000 kilograms of CO_2 emissions.

The energy embodied in the production of inputs such as fertilizer, water, equipment, and building materials is not estimated here and should be considered in future assessments.

Minimal information and consideration of energy use, coupled with adaptations for security and privacy, lead to particularly inefficient configurations and correspondingly elevated energy use and greenhouse-gas emissions. If improved practices applicable to commercial agricultural greenhouses are any indication, such large amounts of energy are not required for indoor Cannabis production.[18] Cost-effective efficiency improvements of 75% are conceivable, which would yield energy savings of about $25,000/year for a generic 10-module operation. Shifting cultivation outdoors virtually eliminates energy use (aside from transport), although, when mismanaged, the practice imposes other environmental impacts.[19] Elevated moisture levels associated with indoor cultivation can cause extensive damage to buildings.[20] Electrical fires are an issue as well.[21] For legally sanctioned operations, the application of energy performance standards, efficiency incentives and education, coupled with the enforcement of appropriate construction codes could lay a foundation for public-private partnerships to reduce undesirable impacts.[22] Were compliant operations to receive some form of independent certification and product labeling, environmental impacts could be made visible to otherwise unaware consumers.

* * *

Current indoor Cannabis production and distribution practices result in prodigious energy use, costs, and greenhouse-gas pollution. The hidden growth of electricity demand in this sector confounds energy forecasts and obscures savings from energy efficiency programs and policies. More in-depth analysis and greater transparency in the energy impacts of this practice could improve decision-making by policymakers and consumers alike.

Figure 1. Carbon Footprint of Indoor Cannabis Production

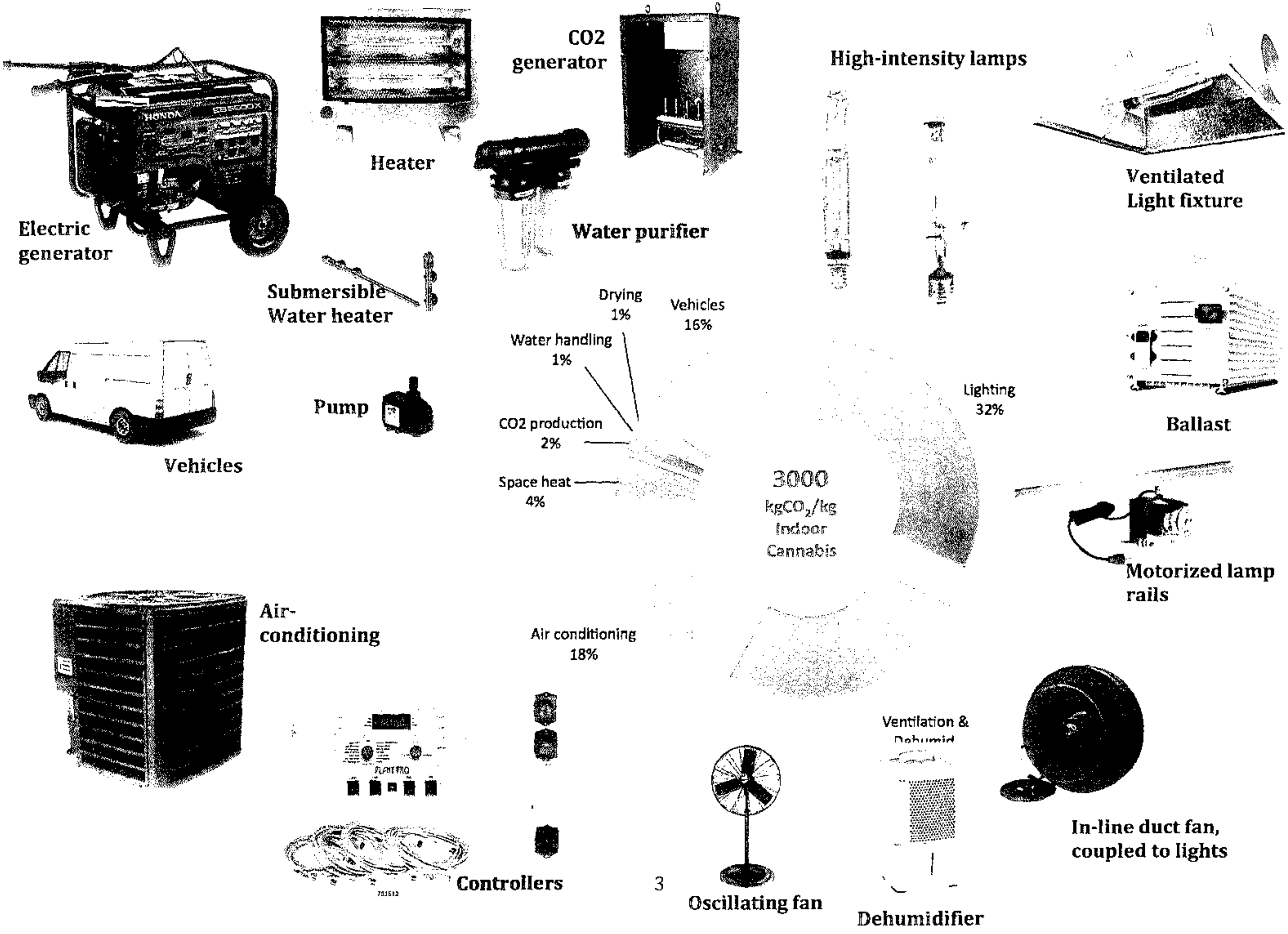

Table 1. Configuration, Environmental Conditions, and Setpoints

Production parameters		
Growing module	16	square feet (excl. walking area)
Number of modules in a room	10	
Area of room	240	square feet
Cycle duration	78	days
Production continuous throughout the year	4.7	cycles
Illumination	*Leaf phase*	*Flowering phase*
Lamp type	Metal halide	High-pressure sodium
Watts/lamp	600	1000
Ballast losses (mix of magnetic & digital)	13%	13%
Lamps per growing module	1	1
Hours/day	18	12
Days/cycle	18	60
Daylighting	none	none
Ventilation		
Ducted luminaires with "sealed" lighting compartment	150	CFM/1000W of light (free flow)
Room ventilation (supply and exhaust fans)	30	ACH
Filtration	Charcoal filters on exhaust; HEPA on supply	
Oscilating fans: per module, while lights on	1	
Water		
Application	40	gallons/room-day
Heating	Electric submersible heaters	
	75	F
Space conditioning		
Indoor setpoint - day	82	F
Indoor setpoint - night	68-70	F
AC efficiency	10.0	SEER
Dehumidification	7x24	hours
CO2 production - target concentration (mostly natural gas combustion in space)	1500	ppm
Electric space heating	when lights off to maintain indoor setpoint	
Target indoor humidity conditions	40-50%	
Fraction of lighting system heat production removed by luminaire ventilation	30%	
Ballast location	Outside conditioned space	
Drying		
Space conditioning, oscillating fans, maintaining 50% RH, 70-80F	7	days
Electricity supply		
grid	85%	
grid-independent generation (mix of diesel, propane, and gasoline)	15%	
Vehicle use		
workers during production	2089	vehicle miles/cycle
wholesale distribution	750	vm/cycle
retail distribution (1 bounce)	3520	vm/cycle

Table 2. Assumptions & conversion factors

Service Levels		
Illuminance*	25-100,000	lux
Airchange rates*	30	changes per hour
Operations		
Cycle duration**	78	days
Cycles/year**	4.7	continuous production
Production module area*	16	square feet (excl. walking area)
Production module volume**	192	cubic feet
Airflow**	96	cubic feet per minute
Modules per room*	10	
Lighting		
Leafing phase		
Lighting on-time*	18	hrs/day
Duration*	18	days/cycle
Flowering phase		
Lighting on-time*	12	hrs/day
Duration*	60	days/cycle
Drying		
Hours/day*	24	hrs
Duration*	7	days/cycle
Equipment		
Average air-conditioning age	5	years
Air conditioner efficiency (SEER)	10	Minimum standard as of 1/2006
Fraction of lighting system heat production removed by luminaire ventilation	30%	
Diesel generator efficiency*	27%	55kW
Propane generator efficiency*	25%	27kW
Gasoline generator efficiency*	15%	5.5kW
Fraction of total prod'n with generators*	15%	
Water use [indoor]*	1	gallons/day-plant
Transportation: Production phase (10 modules)	25	miles roundtrip
Daily service (1 vehicle)	78	trips/cycle. Assume 20% live on site
Biweekly service (2 vehicles)	11	trips/cycle
Harvest (2 vehicles)	10	trips/cycle
Total vehicle miles**	2089	vehicle miles/cycle
Transportation: Distribution		
Amount transported wholesale	5	kg per trip
Mileage (roundtrip)	750	vm/cycle
Retail (0.25oz x 5 miles roundtrip)	3520	vm/cycle
Total**	4270	vm/cycle
Fuel economy, typical car [a]	22	mpg
Annual emissions, typical car [a]	5195	kg CO2
	0.416	kg CO2/mile
Annual emissions, 44-mpg car**	2598	kg CO2
	0.208	kg CO2/mile
Cross-country US mileage	2790	miles
Fuels		
Propane [b]	91,033	BTU/gallon
Diesel [b]	138,690	BTU/gallon
Gasoline [b]	124,238	BTU/gallon
Electric Generation Mix*		
Grid	85%	share
Diesel generators	8%	share
Propane generators	5%	share
Gasoline generators	2%	share
Emissions Factors		
Grid electricity - US [c]	0.609	kgCO2/kWh
Grid electricity - CA [c]	0.384	kgCO2/kWh
Grid electricity - non-CA US [c]	0.648	kgCO2/kWh
Diesel generator**	0.922	kgCO2/kWh
Propane generator**	0.877	kgCO2/kWh
Gasoline generator**	1.533	kgCO2/kWh
Blended generator mix**	0.989	kgCO2/kWh
Blended on/off-grid generation - CA**	0.475	kgCO2/kWh
Blended on/off-grid generation - US**	0.666	kgCO2/kWh
Propane combustion	63.1	kgCO2/MBTU
Prices		
Electricity price - grid (California - PG&E) [d]	$0.390	per kWh (Tier 5)
Electricity price - grid (US, excl. CA) [e]	$0.127	per kWh
Electricity price - off-grid**	$0.390	per kWh
Electricity price - blended on/off - CA**	$0.390	per kWh
Electricity price - blended on/off - US**	$0.166	per kWh
Propane Price [f]	$2.20	per gallon
Gasoline Price - US average [f]	$3.68	per gallon
Diesel Price - US average [f]	$3.98	per gallon
Wholesale price of Cannabis [g]	$4,000	$/kg
Production		
Plants per production module*	4	
Net production per production module [h]	0.7	kg/cycle
US production (2011) [i]	16,974	metric tonnes/y
California production (2011) [i]	5,922	metric tonnes/y
Fraction produced indoors [i]	33%	
US indoor production modules**	1,727,283	
Calif indoor production modules**	602,597	
Cigarettes per kg**	3,000	
Other		
Average new refrigerator	450	kWh/year
	173	kgCO2/year (US average)
Electricity use of a typical US home - 2009 [j]	11,646	kWh/year
Electricity use of a typical California home - 2009 [k]	6,961	kWh/year

* trade and product literature; interviews with equipment vendors
** calculated from other values

Table 3. Carbon footprint of indoor Cannabis Production
(Average US conditions)

	kWh/kg	kgCO2 emissions/kg	
Lighting	1,479	985	32.2%
Ventilation & Dehumid.	1,197	797	26.1%
Air conditioning	827	551	18.0%
Space heat	197	131	4.3%
CO_2 production	54	49	1.6%
Water handling	28	19	0.6%
Drying	73	48	1.6%
Vehicles		479	15.7%
Total	3,855	**3,059**	100.0%

Note: "CO2 production" represents combustion fuel to make on-site CO2. Assumes 15% of electricity is produced in off-grid generators. As the fuels used for CO2 contain moisture, additional dehumidification is required (and allocated here to the CO2 energy row). Air-conditioning associated with CO2 production (as well as for lighting, ventilation, and other incidentals) is counted in the air-conditioning category.

Table 4. Equivalencies

Indoor Cannabis production consumes...	3%	of California's total electricity, and	8%	of California's household electricity	1%	of total US electricity, and	2%	of US household electricity
U.S. Cannabis production & distribution energy cost...	$5	Billion, and results in the emissions of	17	million tonnes per year of greenhouse gas emissions (CO2)	equal to the emissions of	3	million average cars	
U.S. electricity use for Cannabis production is equivalent to that of...	2	million average US homes						
California Cannabis production and distribution energy cost	$3	Billion, and results in the emissions of	4	million tonnes per year of greenhouse gas emissions (CO2)	equal to the emissions of	1	million average cars	
California electricity use for Cannabis production is equivalent to that of...	1	million average California homes						
A typical 4x4x8-foot production module, accomodating four plants at a time, consumes as much electricity as...	1	average U.S. homes, or	2	average California homes	or	28	average new refrigerat ors	
Every 1 kilogram of Cannabis produced using national-average grid power results in the emissions of...	2.8	tonnes of CO2	equivalent to	4.9	cross-country trips in a 44mpg car			
Every 1 kilogram of Cannabis produced using a prorated mix of grid and off-grid generators results in the emissions of...	3.1	tonnes of CO2	equivalent to	5.3	cross-country trips in a 44mpg car			
Every 1 kilogram of Cannabis produced using off-grid generators results in the emissions of...	4.3	tonnes of CO2	equivalent to	7.4	cross-country trips in a 44mpg car			
Transportation (wholesale+retail) consumes...	52	gallons of gasoline per kg	or	$1	billion dollars annually, and	479	kilograms of CO2 per kilogram of final product	
One Cannabis cigarette is like driving...	15	miles in a 44mpg car	emitting about	2	pounds of CO2, which is equivalent to operating a 100-watt light bulb for	17	hours	
Of the total wholesale price...	24%	is for energy (at average U.S. prices)						

Table 5. Indicators (Average US conditions)	per cycle, per production module	per year, per production module	
Energy Use			
Connected Load		3,039	watts/module
Power Density		190	watts/ft2
Elect	2,698	12,626	kWh/module
Fuel to make CO2	0.3	1.5	MBTU
Transportation fuel	37	172	gallons
On-grid results			
Energy cost	592	2,770	$/module
Energy cost		846	$/kg
Fraction of wholesale price		21%	
CO2 emissions	1,988	9,302	kg
CO2 emissions		2,840	kg/kg
Off-grid results (diesel)			
Energy cost	1,196	5,595	$/module
Energy cost		1,708	$/kg
Fraction of wholesale price		43%	
CO2 emissions	3,012	14,094	kg
CO2 emissions		4,303	kgCO2/kg
Blended on/off grid results			
Energy cost	682	3,194	$/module
Energy cost		975	$/kg
Fraction of wholesale price		24%	
CO2 emissions	2,141	10,021	kg
CO2 emissions		3,059	kgCO2/kg
Of which, indoor CO2 production	9	42	kgCO2
Of which, vehicle use			
Fuel use			
During Production		14	gallons/kg
Distribution		39	gallons/kg
Cost			
During Production		$50	$/kg
Distribution		$143	$/kg
Emissions			
During Production		124	kgCO2/kg
Distribution		355	kgCO2/kg

Table 6. Model	Energy type	Penetration	Rating	Number of 4x4x8-foot production modules served	Input energy per module	Units	Hours/day (leaf phase)	Hours/day (flower phase)	Days/cycle (leaf phase)	Days/cycle (flower phase)	kWh / cycle	kWh/year per production module
Light												
Lamps (HPS)	elect	100%	1000	1	1000	W		12		60	720	3,369
Ballasts (losses)	elect	100%	13%	1	130	W		12		60	94	438
Lamps (MH)	elect	100%	600	1	600	W	18		18		194	910
Ballast (losses)	elect	100%	13%	1	78	W	18		18		25	118
Motorized rail motion	elect	5%	5.5	1	0.3	W	18	12	18	60	0	1
Controllers	elect	50%	10	10	1	W	24	24	18	60	2	9
Ventilation and moisture control												
Luminare fans (sealed from conditioned space)	elect	100%	454	10	45	W	18	12	18	60	47	222
Main room fans - supply	elect	100%	242	8.1	30	W	18	12	18	60	31	145
Main room fans - exhaust	elect	100%	242	8.1	30	W	18	12	18	60	31	145
Circulating fans (18")	elect	100%	130	1	130	W	24	24	18	60	242	1,134
Dehumidification	elect	100%	1,035	4	259	W	24	24	18	60	484	2,267
Controllers	elect	50%	10	10	1	W	24	24	18	60	2	9
Spaceheat												
Resistance heat [when lights off]		90%	1,850	10	167	W	6	12	18	60	138	645
Carbon Dioxide												
Parasitic electricity	elect	50%	100	10	5	W	18	12	18	60	5	24
AC (see below)	elect	100%										
In-line heater	elect	5%	115	10	0.6	W	18	12	18	60	1	3
Dehumidification (10% adder)	elect	50%	104	0.4	26	W	18	12	18	60	27	126
Monitor/control	elect	50%	50	10	3	W	24	24	18	60	5	22
Water												
Heating	elect	100%	300	10	30	W	18	12	18	60	19	89
Pumping - irrigation	elect	100%	55	10	5.5	W	1	1	18	60	0	2
Drying												
Dehumidification	elect	75%	1,850	10	139	W		24		7	23	109
Circulating fans	elect	100%	130	5	26	W		24		7	4	20
Heating	elect	75%	1,850	10	139	W		24		7	23	109
Electricity subtotal	elect										2,119	9,918
Air-conditioning											579	2,709
Lighting loads											239	1,117
Loads that can be remoted	elect	100%	1,180	10	118	W					221	1,034
Loads that can't be remoted	elect	100%	450	10	45	W					84	394
CO2-production heat removal	elect	50%	1,118	16.7	34	W	18	12	18	60	35	164
Electricity Total	**elect**				**3,039**	**W**					**2,698**	**12,626**

ON-SITE FUEL	Units	Technology Mix	Rating (BTU/hour)	Number of 4x4x8-foot production modules served	Input energy per module		Hours/day (leaf phase)	Hours/day (flower phase)	Days/cycle (leaf phase)	Days/cycle (flower phase)	MBTU or kgCO2/cycle	MBTU or kgCO2/year
On-site CO2 production												
Energy use	propane	45%	11,176	16.7	671	BTU/ho	18	12	18	60	0.3	1.5
CO2 production --> emissions	kg/CO2										20	93
Externally produced Industrial CO2		5%		1	0.011	gallonsCO2/hr	18	12	18	60	1	3
Weighted-average on-site / purchased	kgCO2										2	10
Weighted average on-site / purchased	kg CO2										9	42

Notes for Tables

[a]. U.S. Environmental Protection Agency. "Emission Facts: Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks." http://www.epa.gov/oms/consumer/f00013.htm [accessed February 5, 2011]

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[d]. PG&E residential tariff as of 1/1/11, Tier 5 http://www.pge.com/tariffs/ResElecCurrent.xls [Accessed February 5, 2011]. In practice a wide mix of tariffs apply, but the relative shares are not known.

[e]. State-level residential prices, weighted by Cannabis production from [Reference 4], with actual tariffs and U.S. Energy Information Administration, "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State," http://www.eia.doe.gov/electricity/epm/table5_6_a.html [Accessed February 7, 2011]

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[i]. See Reference 14 for derivation.

[j]. Total U.S. Electricity Sales: U.S. Energy Information Administration, "Retail Sales of Electricity to Ultimate Customers: Total by End-Use Sector" http://www.eia.gov/cneaf/electricity/epm/table5_1.html [Accessed March 5, 2011]

[k]. California Energy Commission. "Energy Almanac." http://energyalmanac.ca.gov/electricity/us_per_capita_electricity.html [Accessed February 19, 2011]. See also Total California Electricity Sales: California Energy Commission. 2009. *California Energy Demand: 2010-2020 -- Adopted Forecast.* Report CEC-200-2009-012-CMF), December 2009 (includes self-generation).

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1. This report presents a model of typical production methodologies and associated transportation energy use. Data sources include equipment manufacturer data, trade media, the open literature, and interviews with horticultural supply vendors. All assumptions used in the analysis are presented in Table 2. The resultant normalized (per-kilogram) energy intensity is driven by the target environmental conditions, production process, and equipment efficiencies. While less energy-intensive processes are possible (either with lower per-unit-area yields or more efficient equipment and controls), much more energy-intensive scenarios are also possible (e.g., rooms using 100% recirculated air with reheat, hydroponics, and loads not counted here such as well-water pumps and water purification systems). The assumptions about vehicle energy use are likely conservative, given the longer-range transportation associated with interstate distribution. Some localities (very cold and very hot climates) will see much larger shares of production indoors, and have higher space-conditioning energy demands than the typical conditions assumed here. Some authors [See Plecas, D. J. Diplock, L. Garis, B. Carlisle, P. Neal, and S. Landry. *Journal of Criminal Justice Research,* Vol. 1 No 2., p. 1-12.] suggest that the assumption of 0.75kg yield per production module per cycle is an over-estimate. Were that the case, the energy and emissions values in this report would be even higher, which is hard to conceive. Additional key uncertainties are total production and the indoor fraction of total production (see note 14), and the corresponding scaling up of relatively well-understood intensities of energy use per unit of production to state or national levels by weight of final product. Greenhouse-gas emissions estimates are in turn sensitive to the assumed mix of on- and off-grid power production technologies and fuels, as off-grid production tends to have substantially higher emissions per kilowatt-hour than grid power. Costs are a direct function of the aforementioned factors, combined with electricity tariffs, which vary widely across the country and among customer classes. More in-depth analyses could explore the variations introduced by geography and climate, alternate technology configurations, and production techniques.
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12. See Gettman, *op cit.*, at ref 4.
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14. Total Production: The only official domestic estimate of U.S. Cannabis production was 10,000 to 24,000 tonnes for the year 2001. Gettman (*op cit.*, at ref. 4) conservatively retained the lower value for the year 2006. This 2006 base is adjusted to 2011 values using 10.9%/year net increase in number of consumers between 2007 and 2009, per U.S. Department of Health and Human Services (*op cit.*, at ref. 12). The result is approximately 17 million tonnes of total production annually (indoor and outdoor). Indoor Share of Total Production: The three-fold changes in potency over the past two decades, reported by federal sources, are attributed at least in part to the shift towards indoor cultivation [See http://www.justice.gov/ndic/pubs37/37035/national.htm and Hudson *op cit.*, at ref 4]. A weighted-average potency of 10% THC (U.S. Office of Drug Control Policy. 2010. "Marijuana: Know the Facts"), reconciled with assumed 7.5% potency for outdoor production and 15% for indoor production implies 33.3%::67.7% indoor::outdoor production shares. For reference, as of 2008, 6% of eradicated plants were from indoor operations, which are more difficult to detect than outdoor operations. A 33% indoor share, combined with per-plant yields from Table 2, would correspond to a 4% eradication success rate for the levels reported (415,000 indoor plants eradicated in 2009) by the DEA (*op cit.*, at ref 5). Assuming 400,000 members of medical Cannabis dispensaries in California (each of which is permitted to cultivate), and 50% of these producing in the generic 10-module room assumed in this analysis, output would slightly exceed this study's estimate of total statewide production. In practice, significant indoor production is no doubt conducted outside of the medical marijuana system.
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Exhibit 5

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BOTEC
Analysis Corporation

Environmental Risks and Opportunities in Cannabis Cultivation

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BOTEC Analysis Corp.
I-502 Project #430-5d
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Executive Summary

The most important environmental cost of marijuana production (cultivation of cannabis) in the legal Washington market is likely to be energy for indoor, and to a lesser extent, greenhouse, growing. Nearly all of this energy is electricity used for lighting and ventilating, and the energy bill can amount to 1/3 of production costs. While the price of electricity provides growers a market signal for efficient production, it does not reflect the climate effect of greenhouse gas released by electricity production. Though electricity in the Pacific Northwest is some of the lowest-GHG-intensity in the US, it still has a significant "carbon footprint."

Marginal electricity demand is much more carbon-intensive than average demand, since daily peaks are usually met with natural-gas fired generation rather than less GHG-intensive "baseload" hydropower generation. Increased cannabis cultivation indoors can be a noticeable fraction (single-digit percentages) of the state's total electricity consumption. Indoor cultivation that concentrates lighting periods at night will have a much smaller climate effect than if lighting is provided during high-electric use times. Greenhouse production requires much less energy, and open cultivation an insignificant fraction of production costs.

Other environmental effects of cannabis are worth attention, including water use, fertilizer greenhouse-gas emissions, and chemical releases, but are typical of similar horticultural and agricultural operations and should not be primary concerns of the Liquor Control Board (LCB). Even the greenhouse effects are much less important than some other risks (and benefits) of a legal cannabis market. But they should be mitigated when that can be done without substantial sacrifice of other goals, as appears to be the case.

Policies available to the LCB to respond to environmental concerns about cannabis cultivation include adjusting the excise tax on indoor-cultivated marijuana to reflect about 9c per gram worth of global warming effect, labeling low-GHG marijuana as such, encouraging LED lighting development and use, allowing outdoor cultivation, making energy-efficient production a condition of licensing, and leading other state agencies in the development of better technologies and diffusion of best practices to growers. If legal cannabis production moves toward national acceptance, the importance of developing environmentally sound production practices will grow, and policies made now in Washington and Colorado, the early adopters, may shape practices in the new industry nationwide.

Introduction

This memo reviews the main environmental effects of cannabis cultivation (we do not analyze processing or distribution), emphasizing energy and climate issues with a briefer review of other considerations (water use, chemicals, etc.). We find that the predominant environmental concern in marijuana production is energy use for indoor production (less importantly for greenhouse production) and in particular the climate effects of this energy use. We then turn to the main opportunities for growers to reduce these environmental consequences, finding that the most important is substituting greenhouse and outdoor production for indoor operations, and, for indoor production, reduction of electricity use and especially electricity use during the day. We also sketch some ways the Liquor Control Board (LCB) can encourage better environmental practice in this industry.

Indoor cannabis production is very energy-intensive compared to other products on a per-pound basis, less so per unit value. However, environmental risks from cannabis production are nowhere near as salient a part of the overall policy framework for marijuana as (for example) the explosive and toxic hazards of methamphetamine, or the environmental costs of large-scale agriculture, mining, metallurgy, and other industries. Nor should legal cannabis production, licensed and inspected, generate the variety or degree of environmental damage inflicted by illegal production (Barringer 2013). Our bottom line is that environmental considerations should not be a major component of marijuana policy, but they are worth explicit attention and policy design.

Cannabis culture

This section briefly discusses the main methods of cannabis production, in particular growing the plants from which marijuana and other psychoactive materials are derived.

The cannabis varieties of psychoactive interest are dioecious warm-temperate to subtropical annuals, grown for the flowers of the female plant. Cultivation requirements are determined by these properties and the plant's flowering response to a prolonged diurnal dark period.

Cannabis can be grown from seed, with male and female plants separated after germination, or from cuttings (clones). Rooting clones assures an all-female stand of plants and preserves the use properties of the many varieties that have been developed.

The seedlings are grown to the desired size and maturity in a *vegetative phase* and induced or allowed to flower. When unfertilized flowers reach the desired size, they are harvested for further processing. Growing can be hydroponic (in water with dissolved nutrients), in soil (usually outdoors), or in an irrigated artificial growing medium for mechanical support.

Light is provided by the sun outdoors or in a greenhouse, or with electric lighting indoors or sometimes in a greenhouse. Indoor growing requires ventilation, sometimes filtered to reduce odor, to remove heat and humidity. CO_2 may be provided to accelerate growth, usually by venting a propane or natural gas flame into the plants' enclosure

Weeds may be controlled with herbicides outdoors; pests including insects, disease, and fungus may be controlled with chemicals or mitigated with design and management of growing chambers. Cannabis can be grown organically, without chemical fertilizers or pesticides, but at higher cost and usually lower yield.

The high specific value of cannabis flowers, and the desire of illegal growers to minimize and hide the area used for cultivation, has nurtured a labor-intensive, space-concentrated practice for indoor production analogous in some ways to horticulture of orchids and other delicate and exotic plants. This practice may change significantly in a legal operating environment.

Environmental consequences of cannabis production

Energy

The most significant environmental effect of cannabis production, and the one that varies most with different production practices, is energy consumption, especially fossil energy use with climate effects from release of greenhouse gas. Indoor-grown marijuana is an energy-intensive product by weight, using on the order of 2000 kWh per pound of product (for comparison, aluminum requires only about 7 kWh per pound). However, the high unit value of marijuana (approximately $2,000/lb. at wholesale basis[1]) compared to aluminum (~$0.90/lb[2]) means energy is a much smaller fraction of product cost: accounting for the value of the products, it takes 8,000 kWh to make $1,000 worth of aluminum vs. 1,000 kWh for $1,000 of marijuana. Glass is considered an energy-intensive product, but energy costs represent only about a sixth of glass-production costs, about half the level of indoor-grown cannabis.

Total current marijuana consumption in Washington is estimated at about 160 metric tons per year; if this quantity were to be grown indoors with typical practices, marijuana cultivation would increase the state's electricity demand by about 0.8% (using 2010 as a baseline year). Mills estimates that California indoor cultivation currently uses 3% of all electricity in the state (note that California has higher electricity prices than Washington and lacks the electric-intensive industry cluster of the northwest) (Mills 2012). While precise estimates are impossible, marijuana cultivation will be a non-trivial though small component of Washington energy consumption: significant enough to be worth reducing where possible without offsetting losses on other dimensions of value.

Indoor growing

Growing marijuana indoors requires careful and energy-intensive replication of ideal outdoor conditions, including provision of light, fresh air ventilation, cooling (required due to the energy density of lighting and ventilation) and control of pests

---

[1] The wholesale price of marijuana is highly uncertain and currently subject to significant market distortion from the illegal nature of the product. The price in a legal-market framework is likely to be lower.

[2] Based on Aluminum futures prices on the London Metals Exchange http://www.lme.com/metals/non-ferrous/aluminium/

and fungal agents. Indoor growing allows high profits from the typically high-grade product that is produced under controlled conditions and is perceived as more secure and stealthy. Indoor cultivation can also achieve multiple harvests per year; growing marijuana with electricity divorces the process from the constraints of seasonal growing and typical harvest cycles.

Figure 1: Indoor Cannabis culture

An extensive peer-reviewed study details the energy consumption of present day indoor production facilities. Lighting levels are elevated 500-times greater than (for example) recommended for reading, while ventilation occurs at 60-times the rate in a modern home. Power densities are about 2000 W/m^2 of growing area (Mills 2012).

A "grow house," or residential building converted to support cannabis cultivation, can contain 50 – 100 kW of installed lighting. Mills estimates that lighting alone has a power density of approximately 400 W/m^2. Lighting often contains a mixture of metal halide (MH) and high-pressure sodium (HPS) lamps, which must be replaced every 3-4 growing cycles.

CO_2 generators, fueled by natural gas or propane, are often used to raise indoor CO_2 levels and boost plant productivity. Concentrations of CO_2 are often raised to four times natural levels, or ~1600 ppm(v). Mills estimates that CO_2 generators are responsible for 2% of the overall carbon footprint of indoor cultivation. However, given the beneficial effect of heightened CO2 concentration on plant yield, this practice may decrease overall environmental impact per unit of product.

(Illegal indoor production often entails off-grid diesel or gasoline fuel generators. Per unit greenhouse gas (GHG) emissions from these generators are often 3-4-times greater than the relatively low-carbon electricity available in the Pacific Northwest or California. Spills of diesel fuel can pollute local water sources and harm aquatic life.(Gurnon 2005) We expect that legal production will avoid nearly all use of off-grid generation.)

The energy costs of indoor cultivation can account for over 1/3 of total costs for representative production systems depending on a range of factors, including the yield of the growing operation and the cost of electricity (growers in private residences pay much higher prices for electricity than those with commercial or even industrial accounts that would be typical in a legal market framework)(Arnold 2013). Arnold also worked with several Northern California dispensaries with indoor production facilities to determine their energy and carbon intensity. She found that each of three dispensaries had an energy intensity of 2,000 kWh / lb. product, and carbon intensity of 1,000 lb. CO_2/ lb. based on the average grid mix for the area. These figures are lower than Mills', and probably represent energy savings from economies of scale in larger production operations.

Other estimates of lighting intensity are in similar range: (Caulkins 2010) estimates lighting intensity of 430 W / m^2, while typical lighting systems [3] are sold at intensity of ~650 W/m^2. As the layout and spacing of each production facility will differ, these figures will vary. Energy required for ventilation varies more widely; Arnold finds that 9-15% is used for ventilation in a large facility, while Mills estimates that 27% of indoor production energy is for ventilation.

Greenhouse

Greenhouse cultivation demands significantly less energy than indoor cultivation practices, though actual energy intensities vary widely. As sunlight is used for plant photosynthesis, most greenhouse energy consumption is due to heating, though a well-designed greenhouse with built-in thermal inertia can keep itself warm most of the time by sunlight alone. Lighting can be augmented with lamps and may be needed to match the yields from fully indoor growing, particularly in the winter months.

Belgian greenhouses have an energy intensity of approximately 1000 MJ/m^2, which Mills notes is about 1% of his estimate for indoor production(De Cock and Van Lierde 1999). Winter heating in a double plastic greenhouse in Serbia requires 9-14 MJ / m^2 (Djevic and Dimitrijevic 2009). The greenhouse was held between 53-59 °F, while daily temperatures in the region average ~30-40 °F in winter months (Unsigned). This is similar to the climate in much of Washington State.

Several factors affect energy consumption in greenhouses, including greenhouse shape, construction material, as well as heating, shading, and lighting

[3] A typical lighting system can use 1000W of lighting power for 16 ft^2 of production area.

practices. It is unclear whether cannabis growers will choose to heat greenhouses during winter months to increase production, but the high value of cannabis will make it more attractive to do so for that crop than it is for other agricultural products.

A greenhouse for horticulture can include a wide range of design and operational features at correspondingly varying capital and operating costs. The enclosure itself can be plastic film, in one or two layers, over a frame, or glass (single or double pane) in a metal or wood construction. Ventilation is usually by gravity where panes in the roof can be opened, and mechanical shades, automated or manual, can provide photoperiod control and limit heat gain. Growing media include soil, media, or hydroponic tanks. Greenhouse operation has benefited from years of experience growing high-value crops like flowers and out-of-season vegetables and the technology should be easily adopted for cannabis.

Outdoor

Field production of psychoactive cannabis is environmentally similar to growing hemp (non-psychoactive cultivars of cannabis) or other nitrogen-hungry field or row crops. Environmental climate effects include small fossil energy inputs per unit of product, mostly diesel fuel for cultivation, indirect energy use for fertilizer production, and fertilizer N_2O release. We have not estimated the full energy implications of field production in the current draft except to note that they are (i) *very* small compared to greenhouse or indoor production (ii) variable in response to agronomic practices like crop rotation and no-till cultivation that have been developed for other crops. In any case, the small acreage required for Washington MJ production would probably otherwise be used for other row or specialty crops with similar energy requirements.

Greenhouse gas and climate

The energy required for indoor growing (and the smaller amounts used for other methods) almost always leads to greenhouse gas (GHG) pollution that increases global warming. We discuss GHG intensity (climate effect) separately from total energy for two reasons: first, because optimizing indoor production can greatly affect the GHG intensity of cannabis cultivation independently of total energy intensity (see below); second, because climate effects are the major unregulated and unpriced environmental consequences of this industry (and many other industries). Growers pay for electricity and all other fuels, and hence see a built-in incentive to reduce their use to an *efficient* level, but using a more- rather than less-GHG-intensive form of energy does not cost the grower any more, and this distortion of efficient incentives–what economists call a *market failure*–is a standard justification for government action. Charging an additional fee for the GHG from electricity consumption for indoor growers (for example) would fix the market failure and provide the correct incentives for innovation. While the climate impact of cannabis production in Washington will be modest, choices made in Washington now will help shape the development of production technology nationwide and perhaps worldwide, if the movement toward allowing legal production and sale continues.

The Washington electric grid is unusually "low-carbon", mostly hydro-electric and nuclear with only about 17% fossil-fueled, mostly natural gas http://www.eia.gov/electricity/state/Washington/ table 4. The average greenhouse-gas intensity of electricity produced in the state is 135 kg CO_2/MWh. The state is also intertied with the Western USA Grid however, which has a higher carbon intensity. Furthermore, additional loads anywhere on the Western Grid have an impact "on the margin" that is different from the average of the whole grid. The average marginal climate effect of additional electricity demand in the Western Electricity Coordination Council (WECC) region is 486 kg CO_2 / MWh (Siler-Evans, Azevedo et al. 2012), three times the average for the State. The real impact of additional electricity use from cannabis will be close to the marginal factor for WECC, and there is good reason to use marginal costs as indicators of value in cases like this because the consumer's decision to use more electricity rather than less is intrinsically marginal.

Overall, Mills estimates that carbon dioxide emissions are approximately 4600 kg CO_2 / kg indoor cannabis produced but this is based on average national electric GHG-intensity; the figure for Washington production will be much less for the average grid mix (but similar if one takes the marginal WECC emissions factor as discussed above). Using figures derived from (Mills 2012), the Okanogan Cannabis Association estimates that the indoor production of 186 thousand pounds of cannabis, one estimate of state production, would release about 0.4 million metric tons of CO_2(Moberg and Mazzetti 2013), just under one-half of one percent of the total for the state as of 2008.

Indoor production variations could lead to a significant amount of GHG reduction from these average estimates, in particular by concentrating the light periods during the nighttime when demand is low and almost entirely supplied by the low-GHG Northwest baseload plants. This timing also reduces cooling costs from lower outdoor temperatures and the ability to use fresh outside air for cooling.

One set of estimates for the relative contribution of each process to greenhouse gas emissions of indoor cultivation, as well as other process assumptions, is shown in Appendix 1.

Comparison

Using values cited above, we are able to compare high and low estimated values for the energy and GHG intensity of indoor, greenhouse, and outdoor cultivation.

	Energy kWh/kg	**GHG $kgCO_2eq/kg$**

	Low	High	Low	High
Outdoor	(minimal)	(minimal)	(minimal)	(minimal)
Greenhouse	6	580	1	282
Indoor	4400	6100	590	3000

Table 1 - On-site energy and climate intensity of different cultivation methods per kilogram of product (marijuana).

At $30/tonne CO_2e, a common assumed social cost of GHG emissions, these estimates imply climate damage worth between about 1c and 9c per gram of product for indoor growing, less than 1c for other methods. Even the highest figure represents a modest share (no more than a few percent) of the total cost of production: an issue worth thinking about, but not one large enough to require substantial sacrifices of other goals.

Other Environmental Considerations

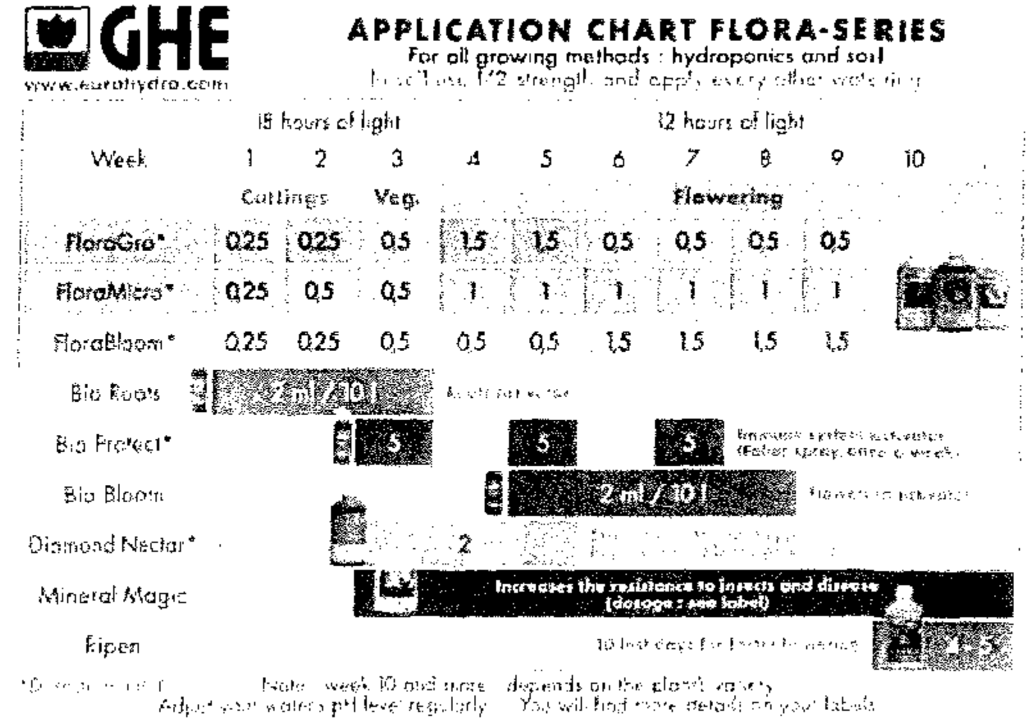
Outdoor

Field production of cannabis is environmentally similar to growing hemp or other nitrogen-hungry field or row crops. Environmental effects include small fossil energy inputs per unit of product, mostly diesel fuel for cultivation; fertilizer runoff and N_2O release, water contamination, soil carbon sequestration, and release of toxic chemicals (herbicides, fungicides, and pesticides) are the other important environmental considerations and only fertilizer manufacturing energy, N_2O and soil carbon have important climate implications. We have not estimated the climate effects of field production in the current draft except to note that they are (i) very small compared to greenhouse or indoor production (ii) variable in response to agronomic practices like crop rotation and no-till cultivation that have been developed for other crops.

Fertilizer

Cannabis requires a nitrogen-rich soil environment. Specific application rates, however, are described only in grey literature. Cervantes lists the following application schedule for hydroponic and soil growth, provided by General

Hydroponics (Cervantes 2006). Figures are given in ml. Fertilizer / l. water.



General Hydroponics gives growers specific fertilizer and additive instructions for their products.

Figure 2: Fertilization recommendations (from (Cervantes 2006)

Soil-grown cannabis requires fewer fertilizer inputs than hydroponic cannabis. Notably, General Hydroponics recommends one-quarter the hydroponic application rate for soil-grown cannabis.

Hemp

Much more information about fertilizer application is available for hemp, an industrial form of cannabis sativa used for industrial and foodstuff products. Hemp has similar nutrient requirements to corn, and requires nitrogen in particular. The British Columbia Ministry of Agriculture and Food (BCMAF) recommends the following maximum application amounts:

Nutrient	Application Amount (kg/ha)
Nitrogen (N)	120
Phosphorous (P)	100
Potassium (K)	160

Table 2: Fertilizer recommendations for hemp (from BCMAF)

Much of this nutrient draw returns to the soil. Consensus among agriculture researchers is that hemp requires a high level of nutrients compared to other crops.

Oregon State University has undertaken an extensive study of the feasibility of industrial hemp production in the Pacific Northwest, including Washington. They note that most research maintains that only soils in high state of fertility produced good crops of hemp. In particular, they recommend adequate application of nitrogen and phosphorus. They provide the following summary of existing literature (Ehrensing 1998):

Country	Year	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
United States	1952	60	30	40
Spain	1955	60	100	70
Italy	1956	40-60	100	70
Netherlands	1957	100-200		
Rumania	1961	50-70	30-60	
Bulgaria	1964	120	90	60
Netherlands	1964	120	80	160-180
USSR	1965	150	90	120
Netherlands	1966	120	100	100
USSR	1966	120	90	90
Rumania	1966	50	100	
USSR	1968	120	90	90
South Korea	1968	100	60	80
USSR	1969	120	90	90
Italy	1975	75-150		
Denmark	1976	140		
France	1982	100-140	80-120	160-200
Poland	1995	90-120	70-100	150-180
United Kingdom	1995	120	100	160

Table 3: Hemp Fertilization Reports from (Ehrensing 1998)

In estimating the cost of hemp production in the Pacific Northwest, OSU applies a fertilization rate of 600 lb. / acre of 16-16-16 (16% each elemental N, phosphate (P_2O_5), and potash (K_2O)) fertilizer.

The Reason Foundation similarly reports application rates in Canada of 55-80 lb. / acre and 30-40 lb. / acre phosphate (Smith-Heister 2008).

Water

Indoor

Indoor cultivation of cannabis is water-intensive, particularly when it is hydroponic. Mills estimates that one cultivation room (22 m^2) requires 151 L / day (Mills 2012). This is equivalent to 2.5 m of water per year (98 in. / yr.) of application. This level of water application is much higher than traditional soil-grown water application.

Hydroponic pollution is also a concern for indoor cultivation. In addition to higher water demand, hydroponic systems produce more nutrient pollution than other growing methods. In Northern California, water used for indoor cultivation contributes to pollution in local streams. Water is often illegally diverted through PVC pipes to nearby grow operations, with negative effect on pH, stream flow, water temperature, and nutrient content (Shafer 2012).

Hop cultivation

To understand the water consumption of outdoor cannabis cultivation, we will infer from two other crop: hops and hemp. Hemp is taxonomically the same species as psychoactive cannabis; hops is a different species of the family *Cannabinaceae*.

Research at Washington State University indicates that 300 -450 gallons of water are needed to produce a pound of hops in the Yakima Valley of Washington. In 1992, all hop acreage in Washington was irrigated (Zepp and Smith 1995). Hops in the Yakima Valley generally consume about 28 inches of water per year, though annual application can exceed 50-60 inches (Extension). 75-80% of total annual water use occurs after mid-June, particularly in late July and early August, with maximum daily water uses of about .5 in / day. These numbers should only serve as guidance: soil type contributes to water holding capacity, while irrigation methods determine frequency and volume.

Hemp cultivation

BCMAF estimates that hemp grown in British Columbia requires 12-15 in. (30-40 cm) of water per growing season or rainfall equivalent (Food 1999). Hemp cultivation in the UK requires 20cm of precipitation per growing season (Cherrett, Barrett et al. 2005).

OSU discusses the water and irrigation requirements of hemp at length, finding that "hemp will almost certainly require irrigation to reliably maximize productivity in the region. The requirement for supplemental irrigation will place hemp in direct competition with the highest value crops in the PNW [Pacific Northwest], limiting available acreage." They also note that hemp yield is strongly dependent on the amount of rainfall during June and July (Ehrensing 1998).

As large-scale hemp production has generally been centered in areas with significant rainfall, very little information is available about hemp irrigation. While 33% of cropland in the PNW is irrigated, only 20.5% of cropland in Washington was irrigated in 1992. The PNW faces water deficits, and new irrigation is unlikely.

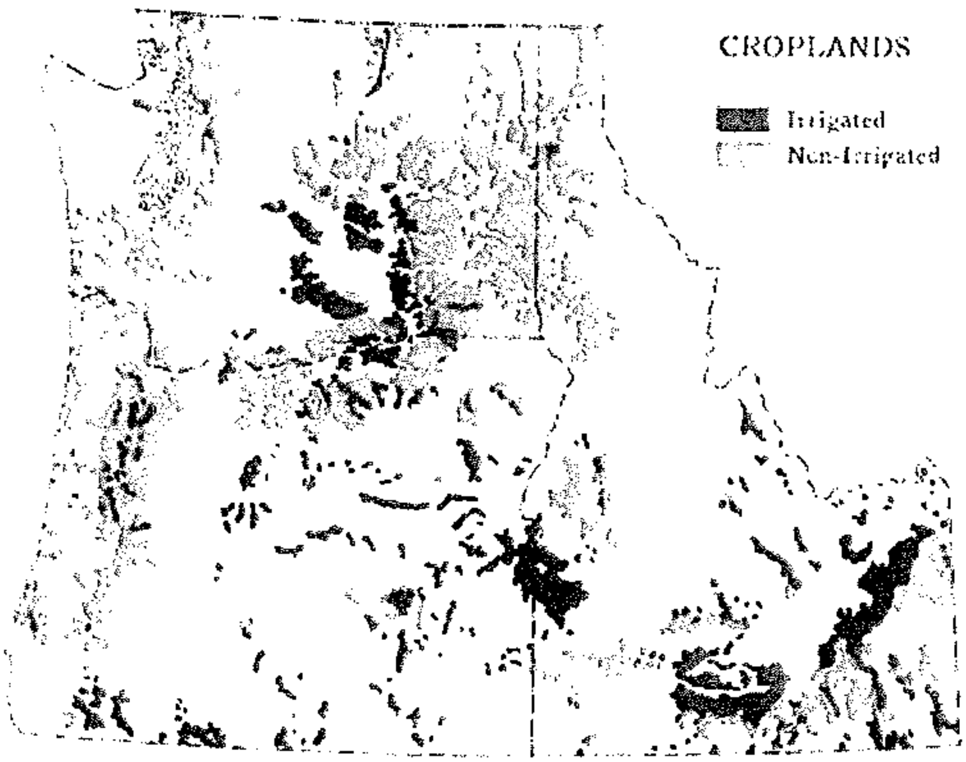


Figure 3: Distribution of irrigated and non-irrigated cropland in the PNW from (Jackson and Kimmerling, 1993)

Table 4. Cropland area in the Pacific Northwest in acres (1992 Census of Agriculture).

	Irrigated	Non-Irrigated	Total	% Irrigated
Idaho	3,260,006	3,041,856	6,301,862	51.7
Oregon	1,622,235	3,415,529	5,037,764	32.2
Washington	1,641,437	6,357,982	7,999,419	20.5
Total PNW	6,523,678	12,815,367	19,339,045	33.7

OSU believes that hemp cultivation will probably occur west of the Cascades because of water availability:

> With early spring planting, it may be possible to grow hemp using available soil moisture and rainfall in some areas west of the Cascades, much like spring cereal grains. Risks associated with such production will be high and yields may be quite variable from season to season ... Reliable irrigation can, however, reduce weather risks associated with rainfed production. Irrigation is not only an additional economic cost of production, but is also an environmental concern, especially considering recent controversies surrounding agricultural water use and increasing demand for in-stream water rights in the PNW (Ehrensing 1998).

Precipitation in Washington is very limited east of the Cascade Mountains. However, the state's extensive infrastructure of dams and irrigation in that region probably affords ample water for the small acreage that may be devoted to marijuana, and the climate is more suitable during the summer.

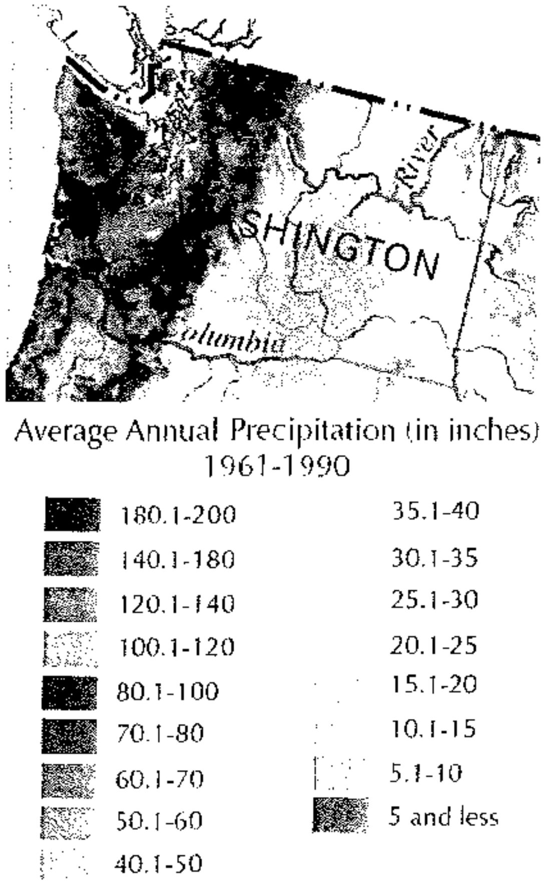


Figure 4: Rainfall in Washington

Pesticides/herbicides/fungicides

Under draft LCB regulation, all usable marijuana for sale in the State of Washington must carry a warning that discloses all pesticides, herbicides, and fungicides or other compounds used for pest control or plant disease in production or processing (2013). Current indoor cultivation often employs pesticides and herbicides (Cervantes 2006). control of chemical residues in cannabis products is considered in another report in this project; the environmental issues are only application drift and water (runoff and groundwater) pollution by agricultural chemicals (but see below regarding illegal vs. legal production general environmental issues).

Hemp cultivation

No pesticides or herbicides are registered for hemp or cannabis. BCMAF notes that hemp is freer of pests than other crops, while weeds can be reduced to virtually zero under a dense hemp canopy (Food 1999). OSU concurs: they find that herbicides and pesticides are not commonly used in hemp production, and significant crop losses from pests are not common. Because of these qualities, OSU believes that hemp can be used for weed suppression, noting "Weed suppression with minimal pesticide use is potentially one of the greatest agronomic and environmental benefits of growing hemp in rotation with other crops." Birds, however, feed voraciously on cannabis seeds and their feeding can lead to substantial crop losses (Ehrensing 1998).

OSU cautions that the introduction of new crops such as hemp to the PNW region can result in unforeseen pest problems: "High-density planting, increased fertilizer use, and irrigation have often increased incidence of pest problems in other crops, and such problems should be anticipated with intensive hemp production."

The following pests are commonly associated with hemp:

Pseudomonas syringae pv. cannabina (bacteriosis of hemp)

Xanthomonas campestris pv. cannabis (leaf spot of hemp)

Fusarium oxysporum f.sp. cannabis

Pseudoperonospora cannabina (downy mildew of hemp)

Orobanche spp. (broomrape) (Cherrett, Barrett et al. 2005)

Other Toxics

Heavy metal and toxins from lighting

Lighting materials used in indoor cannabis cultivation have environmental risks if not properly managed for disposal. High-intensity discharge (HID) bulbs are not recyclable; each bulb contains approximately 30 mg of mercury and other toxins. Mercury is a neurotoxin, and is recognized as extremely toxic, particularly in gaseous form. The Okanogan Cannabis Association estimates that indoor cultivation of cannabis could produce 46,000 HID bulbs each year in Washington (Moberg and Mazzetti 2013).

Using productivity assumptions in Mills, we estimate that there is the potential for 30 mg of mercury pollution per kg of cannabis product if proper disposal is not practiced. However, other lighting applications generate waste lamps that need management outside the standard municipal waste stream and this recycling/disposal system could serve as well for cannabis lighting waste.

Legal vs. illegal cultivation

Rapid expansion of illegal outdoor marijuana cultivation in northern California, including cultivation on public land, has become recognized as a source of serious environmental damage, from wildlife poisoned by pesticides to overdrafted and polluted rivers to deforestation and erosion (Shafer 2012; Barringer 2013). As mentioned previously, spills of diesel fuel often pollute local water sources. The

North Coast Journal describes the diesel generators often employed for off-grid electricity production in Humboldt County:

> The diesel generators supplying power for the 1,000-watt grow lights can be as big as a small pickup truck. They are sometimes buried underground, which can be a fire hazard, or rigged with plastic water tubing instead of proper fuel lines. They are often placed in dubious locations, such as right beside creek beds -- greatly increasing the potential for contaminated water -- because the depth and the surrounding trees help to muffle the machines' drone. Some growers even use water tanks to store the diesel fuel, officials said.(Gurnon 2005)

An important environmental advantage of legal, licensed, cannabis production will be its displacement of environmentally damaging practices by criminals and unregulated parties. We are not able to quantify these benefits but believe them to be significant.

Options for Environmental Protection

This section highlights management practices that can reduce the environmental footprint of cannabis production.

Energy-Efficiency Measures

Outdoor cultivation of cannabis does not raise important energy issues different from other crops. Conventional good agronomic practice such as low-till/no-till, erosion and runoff control, careful control of nitrogen application and timing, integrated pest management, and the like all apply and expertise in these practices is available from county agents and extension services. It is unlikely that the LCB will want to develop this kind of expertise or micromanage outdoor growing for environmental effects.

Excellent guides exist for energy efficiency measures in greenhouses, for example (Bartok 2005). In particular, greenhouse design should consider the effects of glazing materials on heat loss and light transmission, ways to reduce infiltration and nighttime heating losses, greenhouse heating units, the effect of heat distribution on heating costs, ways to maximize space utilization, using efficient circulation and ventilation fans, and how supplemental lighting can reduce energy requirements (Sanford 2010). Energy consumption involves tradeoffs with plant yield and other agronomic needs. Given the high value of cannabis, growers face a strong incentive to use more energy to increase yields than growers of other products.

Efficient greenhouse design is strongly dependent on location and climate, but several themes for good design emerge. Sanford 2010 recommends high efficiency condensing heaters, effective space utilization, basket fans for air circulation, control systems, and energy audits to reduce consumption. In particular, curtain systems can dramatically reduce energy costs. Curtain systems also allow growers to tightly control the amount of light their plants receive, enabling photodeprivation and other advanced growing techniques. (Sanford 2010; Sanford 2010)

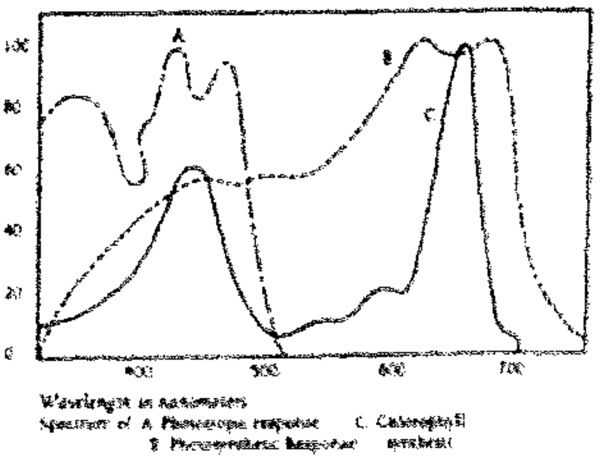
Indoor operations occur in buildings covered by existing Washington building regulations and conventional energy conservation practices such as insulation. The most important opportunities for environmental benefit lie in more efficient lighting equipment and timing to avoid peak use periods.

LEDs for indoor cultivation

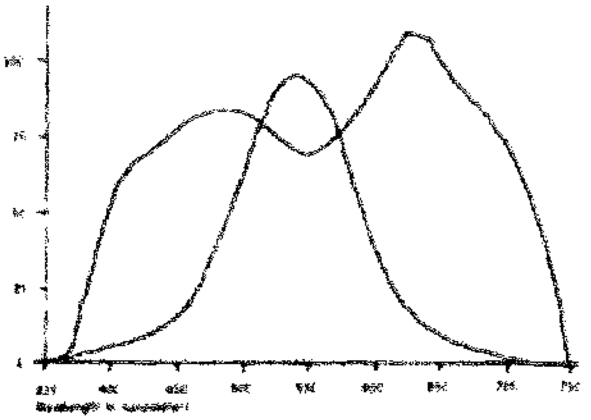
Light-emitting diodes (LEDs) have several advantages over high intensity discharge (HID) or high pressure sodium (HPS) lighting: lifetimes in excess of 100,000h, small size, specific wavelength, adjustable light intensity and quality, and high conversion efficiency (with low thermal losses) (Yeh and Chung 2009).

Plant growth depends specifically on the amount of photosynthetically active radiation (PAR) it receives. Plant varieties have specific PAR spectra, which differ from the sensitivity of the human eye. Chlorophyll molecules absorb red and blue wavelengths most efficiently. Green light, a major constituent of white light and the peak of the solar spectrum and human vision, is not as useful for plant growth. Because plants have different spectral preferences than people, the general lighting that is optimized for lumen output may not be ideal for plant growth. Agricultural lighting is a sub-field of the lighting industry and uses specially tuned light sources to match the PAR spectrum.

In general, the more energy that can be directed into wavelengths plants can use, the more product per kWh will be produced (and the lower the resulting GHG intensity of the product), and LEDs offer not only high overall light output-per-watt efficiency (horticultural LED arrays can provide three times more light output per watt of input power on an area-equivalent basis than HID lamps (Morrow 2008)) but also the potential to "tune" the emitted spectrum to plant needs.



This chart shows the exact level that A. Phototropic response, B. Photosynthetic response and C. Chlorophyll synthesis take place.



The single humped line in the center of the graph represents the visible light spectrum seen by the human eye. The dual humped line represents the spectrum cannabis needs to grow.

Fig. 5: The PAR for cannabis from (Cervantes 2006)

Unfortunately, commercially available LEDs are not yet optimized for plant growth. Yeh 2009, however, argues that LEDs are the first light source to provide true spectral control, allowing wavelengths to match to plant photoreceptors to optimize production as well as to influence plant morphology and composition. In addition, LEDs are easily integrated into digital control systems and can be dimmed (Yeh and Chung 2009). This adaptability, along with lower waste heat production, means that LEDs have the potential for very large energy savings in comparison with existing lighting technologies.

While luminous efficacy is an imperfect measure of a lamp's ability to deliver PAR due to spectral mismatch, the following values are representative of overall efficiency of light production:

Lighting Type	**Overall luminous efficacy (lm / W)**
100 W tungsten incandescent (120V)	17.5
LED, theoretical limit	~400
Available 8.7 W LED (120V)	69-93
Metal halide lamp	65-115
High pressure sodium	85-150

Table 5: Lighting source comparison from (Luminous efficicacy: Retrieved May 29, 2013, from http://en.wikipedia.org/wiki/Luminous_efficacy#Lighting_efficiency.)

Substitution and Complementarity

Cannabis consumption also has indirect impacts on consumption of other goods; it is presumably a substitute for such synthetic cannabinoids as Spice and K2, and a complement to Doritos and unbaked chocolate-chip cookie dough. Whether it complements or substitutes for the consumption of various other psychoactives remains unknown, and the answer need not be the same for all drugs or all user types. (See Boyum *et al.* 2011 and references there.) If it were to turn out that cannabis substituted directly for alcohol (a point on which the research literature is divided and inconclusive) that substitute would create some offsetting environmental benefits/ Beer brewing also has energy demands (the energy requirements for one marijuana "joint" are approximately equal to those for 18 pints of beer (Mills 2012)). This means that any environmental impacts from increased marijuana consumption in a legal market framework could be partially mitigated from substitution away from alcohol. The benefits of substituting cannabis for methamphetamine would be even greater. But since even the signs of the relevant cross-price elasticities are unknown, this analysis does not include this effect.

Recommendations

The following recommendations describe regulations, enforcement mechanisms, collaborations, and tax schemes that promote environmentally responsible cultivation of cannabis. LCB should consider feasibility, enforceability, and potential for market transformation when adopting a portfolio of environmental policies.

LCB's tools are primarily regulatory. Regulatory practice can be categorized into four distinctive approaches: process-specifying, product-specifying, outcome-specifying, and incentive-based. *Product* regulation allows and forbids products on an all-or-nothing basis; an example is the prohibition of wooden cutting boards in restaurants. *Process* regulation requires specific protocols, for example that restaurants wash dishes in a dishwasher using water above a certain temperature. *Outcome* regulation specifies properties of a product or process without requiring that they be achieved in any particular way; an outcome-based regulation for food could be a maximum allowed bacteria count for cutting boards, that the operator can meet by disinfectants, careful sanitation and management of contamination sources, or any other way. Finally, *incentive-based* regulation gives the producer consequential encouragement to provide more of a desired outcome but without (in principle) a minimum level of achievement. An example of this is the A,B,C hygiene ratings health departments award to restaurants in the expectation that an A rating will increase sales enough to make it worth it for most restaurants to achieve it, even though some restaurants' clientele may prefer the combination of price and risk resulting represented by a C score.

In general, policy analysts favor these practices in the reverse of the foregoing order, with incentive methods most preferred. The advantages of the later-listed approaches is that they preserve incentives for innovation while focusing on the specific types of benefit the regulatory program is intended to obtain.

Despite the regulatory orientation of the LCB's marijuana program as currently conceived, we also include recommendations for non-coercive policies (advice, consulting, and research) that can improve the industry's environmental practice. Some of these may benefit from collaboration with other state agencies and non-profits.

Legal, licensed outdoor growing has the lowest environmental impact.

The LCB should consider allowing outdoor growing as either promises significant environmental advantages and lower production costs than indoor cultivation. Process regulations for security might lead to better overall results than outlawing field growing altogether.

Greenhouse cultivation promotes significant environmental protection relative to indoor growing

Greenhouse cultivation of cannabis entails lower energy consumption, GHG production, water consumption, wastewater production, fertilizer application, and toxic risks than indoor cultivation. LCB should promote greenhouse cultivation of cannabis, including cultivation in eastern Washington where the climate (hours of sunshine)) is more favorable. Allowing production in standard greenhouses, rather than requiring new construction of high-security greenhouses, would encourage substitution away from environmentally problematic indoor growing.

Recognize the high GHG intensity of indoor growing with a differential tax

Energy efficiency and GHG reduction for indoor growing, where it matters most, can be pursued by outcome regulations such as (for example)licensing only operations meeting maximum electric consumption per growing area standards. Growers already have economic incentives for efficient use of electricity, but a main 'missing piece' of this framework regards GHG emissions, which as we have seen can vary significantly across production practices, are especially high for indoor operations, and are not reflected in electricity prices. A simple recognition of the distinctive climate effects of indoor growing would be to increase the producer tax on indoor marijuana by an amount that reflected (approximately) its respective carbon footprint. At $30/tonne of CO_2-a typical value in carbon markets-and assuming average Washington electricity GHG intensity and our "high" value for electric use per unit of product, this would be about 9c per gram of marijuana based on the marginal emission factor of Washington electricity. This amount would not ruin the competitiveness of indoor production but would provide a gentle incentive and have considerable symbolic value. The current cost of commercial electricity for cannabis production is about $400 per kilogram of finished product. This additional climate fee would amount to approximately a 20% surcharge on electricity use. The status quo for indoor growing is on residential electricity accounts, with average rates that are 9% higher than the average commercial rate in Washington. Climate fees would essentially preserve (or slightly increase) the status quo incentives for energy efficiency.

Collaborate with the Washington State Energy Office, Utilities and Transportation Commission, and Washington State University, in the development and diffusion of lower-energy production practices.

Two technology areas for energy reduction and climate protection are especially promising: LED lighting for horticultural application, and energy efficiency measures for greenhouse heating. The Washington State Energy Office, located in the Department of Commerce, runs the State Energy Program that provides funding for energy technologies.

Develop LEDs for cannabis applications

LED developed for horticultural applications have the potential to significantly reduce lighting energy for both indoor and greenhouse applications. However, commercial development to date has focused on producing white light, rather than red/blue ("pink") LED arrays optimized for horticulture. LCB, the state universities' engineering and agriculture departments, and the Washington Department of Commerce could collaborate to advance commercialization of these technologies, serving as a critical link among LED consumers, academic researchers, and manufacturers.

Develop region-specific best practices for greenhouse energy efficiency

Cost-effective energy efficiency measures are driven in large part by regional climate. While University extension programs in Wisconsin and Connecticut have developed best practices for greenhouse efficiency, to our knowledge no similar effort has been performed in the Pacific Northwest. LCB should work with the State Energy Office or Washington State University to develop best practices suited to greenhouse cultivation of cannabis. Such a study should employ publicly available energy model software, such as EnergyPlus, to accurately model the effect of building material, glazing, orientation, layout, heating systems, and shading on energy consumption in targeted cultivation areas. Attention should also be given to calculating a benefit-cost (B/C) ratio for efficiency measures. LCB should also seek industry input in developing these best practices.

Encourage time-of-use pricing with lower rates for night-time electric use

Off-peak electric usage in a system like Washington's, where baseload power is very low-carbon, has many benefits including reduced GHG emissions relative to daytime use. Smart meters and nighttime lighting in indoor growing facilities can encourage growers to move a significant amount of the electric usage to this environmentally favorable period.

Collaborate with Washington State University and other stakeholders to continue research on environmental impacts

Quantification of environmental impact in this report has relied on grey literature, craft-skill descriptions, and a small but growing set of academic and consulting reports. As the cannabis industry matures in Washington, academic and industry agricultural researchers should continue to measure the environmental impact of cannabis production methods. This research can be used to refine future regulation and drive environmentally friendly production methods.

Consider labeling of "climate smart" or "environmentally friendly" cannabis for public sale in Washington

Draft LCB regulations entail labeling regulations for cannabis sold publicly. LCB should consider branding cannabis that excels on environmental grounds, similar to the ENERGY STAR program administered for the U.S. Environmental Protection Agency for household appliances (2013). Such labeling programs, which affix a readily identifiable label among the most efficient products, can drive environmentally responsible purchasing and encourage a "race to the top" among producers. LCB could allow labeling for on energy/GHG consumption ("climate smart"), pesticide application ("environmentally friendly"), or a hybrid indicator.

Production enforcement mechanisms can promote environmental protection

Many of the most environmentally harmful practices in cannabis cultivation arise from a lack of information among regulators and the secret nature of cultivation. These include water diversion, water disposal, pesticide application, and electricity generation from on-site diesel generation. LCB should take advantage of the permitting process and information collection procedures to mitigate environmental damage.

Inspections of permitted facilities can ensure compliance with environmental regulation. In particular, LCB or other agencies should ensure that no illegal water diversion takes place, that only permitted pesticides, herbicides, or fungicides are being used for cultivation, and that diesel generation is properly permitted or installed. Inspections are supplemental to other environmental process regulation, and may overlap with other State agency jurisdiction.

While we cannot review the extensive literature on regulatory practice here, it's worth noting that "enforcement" regimes can vary widely in the underlying philosophy of their implementation, from strict defect-finding and punishment to a more complex regime in which inspectors see their job as not only police officers but 'production engineering consultants' providing information on best practices and opportunities to improve performance within the legal range.

Process Regulations can promote environmental protection

In addition to or in place of the tax differentials described above, a mechanism widely regarded as the most efficient generic approach to environmental regulation, LCB can use its permitting authority to enforce process regulations for cannabis cultivation. In particular, LCB should consider banning practices that promote toxic environmental releases, such as diesel generation, improper lighting disposal, and improper water disposal. Such regulations may overlap with or be redundant to other State or Federal regulations.

LCB should require all electricity be grid-connected

As diesel spills relating to on-site electricity generation can pollute waterways, LCB can require that all production facilities draw their electricity from the grid (with perhaps an exception for off-the-grid solar and other small-scale renewable sources). This would remove the incentive for producers to employ on-site fossil-fuel generation. It would also subject producers to Washington's increasing block rate structure electricity tariff, which increased the economic incentive to employ energy efficiency technology.

LCB can establish lighting disposal regulations

Given the high potential for mercury release from HID bulbs, LCB should ensure proper disposal of bulbs used for cannabis production. As HID bulbs are not recyclable, LCB could mandate a separate lighting disposal stream to ensure that bulbs do not cause air or water contamination.

Appendix 1: Figures from Mills 2012

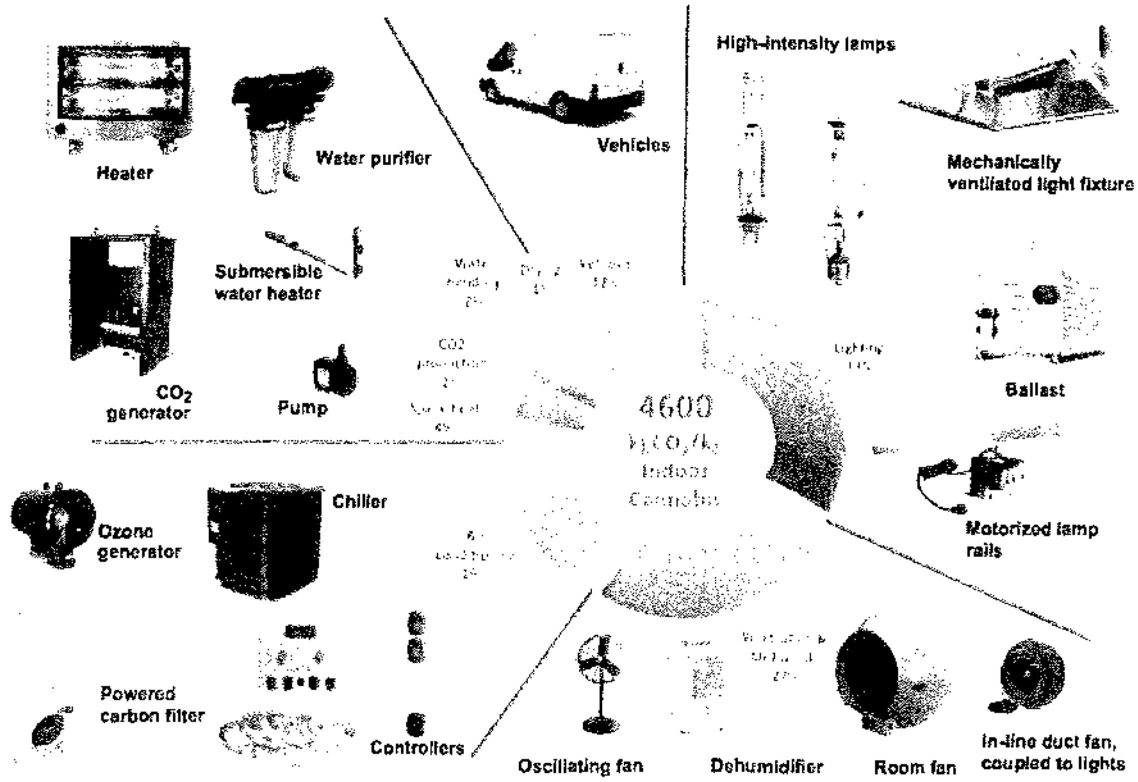


Fig. A1 - Relative contribution of energy-consuming appliances to overall CO_2 emissions for indoor production of cannabis.

Table A1
Configuration, environmental conditions, set-points.

Production parameters		
Growing module	1.5	m^2 (excl. walking area)
Number of modules in a room	10	
Area of room	22	m^2
Cycle duration	78	days
Production continuous throughout the year	4.7	cycles
Illumination	Leaf phase	Flowering phase
Illuminance	25 klux	100 klux
Lamp type	Metal halide	High-pressure sodium
Watts/lamp	600	1000
Ballast losses (mix of magnetic & digital)	13%	0.13
Lamps per growing module	1	1
Hours/day	18	12
Days/cycle	18	60
Daylighting	None	none
Ventilation		
Ducted luminaires with "sealed" lighting compartment	150	CFM/1000 W of light (free flow)
Room ventilation (supply and exhaust fans)	30	ACH
Filtration	Charcoal filters on exhaust; HEPA on supply	
Oscilating fans: per module, while lights on	1	
Water		
Application	151	liters/room-day
Heating	Electric submersible heaters	
Space conditioning		
Indoor setpoint — day	28	C
Indoor setpoint — night	20	C
AC efficiency	10	SEER
Dehumidification	7x24	hours
CO_2 production — target concentration (mostly natural gas combustion in space)	1500	ppm
Electric space heating	When lights off to maintain indoor setpoint	
Target indoor humidity conditions	40–50%	
Fraction of lighting system heat production removed by luminaire ventilation	30%	
Ballast location	Inside conditioned space	
Drying		
Space conditioning, oscillating fans, maintaining 50% RH, 70–80F	7	Days
Electricity supply		
grid	85%	
grid-independent generation (mix of diesel, propane, and gasoline)	15%	

Fig. A2 - Assumptions and inputs for process analysis of indoor cultivation.

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Exhibit 6

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Water Boards

Fact Sheet

Marijuana Cultivation on the North Coast Threatens Water Quality and Wildlife

Cultivation of marijuana in the North Coast Region has grown exponentially in recent years, both in the number of grows and the size of grow operations. The growing operations are appearing on both private and public land.

The North Coast Regional Water Quality Control Board (Regional Water Board) is not interested in entering the debate over the legality of growing marijuana in California, other than to note that any growing operation on public land is illegal regardless of the crop. The Regional Water Board has jurisdiction over discharges of waste that could affect waters of the State, regardless of what activity is generating the waste.

The Regional Water Board has serious concerns about the water quality impacts from the dramatic increase in growing activity on both public and private land.

The Problem

Growers have engaged in a variety of activities that can threaten or damage riparian and aquatic habitat, including:

- grading, terracing, dam, and road construction without permits, leading to the filling of streams through erosion and sediment deposition;
- deforestation and habitat fragmentation;
- illegal use of rodenticides, fungicides, herbicides and insecticides;
- use of soil amendments and fertilizers in situations where run off to surface waters may occur;
- discarding of trash and haphazard management of human waste;
- substandard storage of hazardous materials such as diesel and gasoline; and
- unauthorized diversion of water from streams.

These activities impair beneficial uses of the water, from municipal drinking water to swimming, and from agriculture to preserving habitat for endangered fish and wildlife.

Isn't Marijuana Cultivation a Big Economic Boost to the Region?

That may be true, but growers are required to follow the same rules as every other industry. Water quality, fish and wildlife are public trust assets that shouldn't be sacrificed for private economic gain.

How Big is The Problem?

No one knows the true scope of the increased growing activity and the related quantity of water being diverted from local streams, because most growers do not register or apply for permits from the various agencies involved in protecting water quality, existing water rights and wildlife.

A Department of Fish and Wildlife study of two small watersheds in Humboldt County using aerial imagery indicates that the number of acres devoted to marijuana growing almost doubled from 2009 to 2012, with an estimated 550 individual growing operations and 19,000 plants in each watershed.

What's Being Done About It?

There are existing appropriate permits that should be obtained to make sure that site development activities are done in a manner that is consistent with state and federal law. The attached information sheet identifies water quality concerns and necessary permits and explains how to comply with their requirements for site development and reporting diversions of water. These permits and requirements apply to any site preparation work, regardless of crop.

In addition, the Regional Water Board staff is developing a category for medicinal marijuana as part of its Agricultural Lands Discharge Program that will provide authorization for discharges of waste if water quality protection requirements are met. This will provide permit coverage for growing operations on private lands. Discharges of waste on public lands are not authorized. Under the USFS Waiver (*Waiver of Waste Discharge Requirements for Nonpoint Source Discharges Related to Certain Federal Land Management Activities on National Forest System Lands in the North Coast Region*, Order No. R1-2010-0029), nonpoint source discharges of waste to waters of the state from activities associated with timber harvesting, national forest system roads, grazing, recreation, vegetation manipulation, restoration, and fire suppression are authorized subject to the requirements and conditions of the Waiver. Discharges of waste from site development and growing activities on USFS land are not authorized and are subject to immediate enforcement actions under the California Water Code.

The State and Regional Board are working to educate the public and growers about proper permitting and growing practices. Additionally, local, state and federal agencies, including the State and Regional Board are working together in task forces to find illegal growing operations and enforce applicable laws.

What Can the Public Do to Help?

The public can help in two ways: making friends and neighbors aware of the issues; and reporting water quality violations they see to the North Coast Regional Water Quality Control Board.
To file an environmental complaint, contact Stormer Feiler at the North Coast Regional Water Quality Control Board (707) 543-7128 or email stormer.feiler@waterboards.ca.gov, or
Submit an environmental complaint to Cal/EPA via the following web link:
http://www.dtsc.ca.gov/database/CalEPA_Complaint/index.cfm
(This site can also be used for water right complaints)

Following is an informational sheet on how to comply with necessary permitting requirements:

To: Interested parties and agencies

SUBJECT: 215 Grow-Related Activities Which May Need a Regional Water Board Permit or Special Planning for Water Quality Protection

Agricultural activities, including marijuana production, can harm our State's waters if they are not carried out properly. If you are planning to develop land to grow marijuana in compliance with State law and local ordinances, there are several agencies you should contact BEFORE you get started. The North Coast Regional Water Quality Control Board (Regional Water Board) is one of the agencies that may need to review and permit the activities associated with your project. The State Water Resources Control Board's Division of Water Rights is another. Before you start developing your property to conduct your growing project, here is a series of questions you should ask yourself to see whether your activities may need a permit from the Regional Water Board.

1) Will I be doing any work that involves digging or heavy equipment work in a watercourse/wetland or in a location where rain could wash dirt into a year-round or seasonal creek, river, wetland, or wet feature?
2) Will I be placing any type of material or structure in a stream, either year-round or seasonal (e.g., stream crossing, culvert, water intake, dam, etc.)?
3) Will I be diverting water from a stream?
4) Will I be building any roads, landings, terraces or other features that involve placement of earthen fill material on my land?
5) Will I be grading, excavating, or otherwise moving earth on my property?
6) Will I be using and/or storing pesticides, herbicides, fertilizers, fuel, or other chemicals on my property?
7) Will I be generating and/or storing solid waste (e.g., amendment bags, boxes, containers, dead plant material, waste soil, etc.) on my property?

If you have answered yes to questions 1, 2, or 3, you will probably need a permit from the State or Regional Water Board, and we suggest that you contact us at (707) 576-2220 to get further information about how to apply for the appropriate permits. Note that any person who discharges waste to waters of the State without a permit may be subject to enforcement and possible penalties. Information about California water rights is available on the State Water Resources Control Board's Division of Water Rights website at: http://www.waterboards.ca.gov/waterrights/. Any diversion and use of water without a water right, and a failure to report the diversion and use of water are also subject to enforcement and penalties.

If you have answered yes to questions 4 or 5, you may need a permit from the Water Boards, and your project may harm water quality if not constructed carefully, subjecting you to enforcement and possible penalties. It would be advisable to hire a qualified professional with experience in erosion control to help you design and construct your project in a way that will avoid allowing dirt to get into waterways. We recommend that you contact the Regional Water Board to review your project and identify whether your project will need a water quality permit.

Finally, a yes answer to question 6 or 7 will not require that you get a permit from the Water Board if you manage these materials responsibly and consistent with the manufacturer's specifications. We recommend that as you design your project, you consider and identify suitable location(s) on your property, possibly within a container or structure, where you can safely contain such materials away from surface and/or ground waters in a manner that eliminates the possibility of discharge.

Dumping or allowing dirt or other wastes to enter streams or groundwater is illegal, as is discharging any of the materials noted above to streams or groundwater. If you have any questions or would like assistance in reviewing your compliance with water quality laws and requirements and/or need for permits, please contact the Regional Water Board at (707) 576-2220. Information about the Regional Water Board can be found at our website: http://www.waterboards.ca.gov/northcoast/.

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