

# **BUENAS: An Overview and Introduction**

**My Ton  
CLASP Global Research**

**Accelerating Market Transformation through  
Standards and Labeling in India**

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# Presentation Agenda

- BUENAS in a nutshell
- Origin and History
- Overview of Bottom-up Approach
- Current and Past Applications
- Recent Enhancements
- Future Directions



# **BUENAS in a Nutshell**

## **What is it?**

- **BUENAS (Bottom Up Energy Analysis System) is an end use energy forecasting model developed by Lawrence Berkeley National Laboratory (LBNL) in the United States.**
- **BUENAS is designed as a policy analysis tool which creates scenarios differentiated by the level of actions.**
- **BUENAS models energy demand by various types of energy consuming equipment and aggregate the results to end use, sector or national level.**
- **It covers multiple countries, models energy demand at the technology level and forecasts efficiency improvement based on specific targets known to be achievable.**

# **BUENAS: Origin and History**

## **Activities Summary:**

- **The Collaborative Labeling and Appliance Standards Program (CLASP), the International Copper Association (ICA) and the United States Department of Energy (USDOE) supported the development of BUENAS.**
- **The first version of the model was completed in 2008 and covered the entire world, divided into 10 regions.**
- **The 2008 version relied heavily on extrapolation of ‘marker country’ data to represent an entire region.**
- **The 2008 version of the model made rough estimates of some end uses where equipment data were not available in order to cover the great majority of energy demand in buildings.**

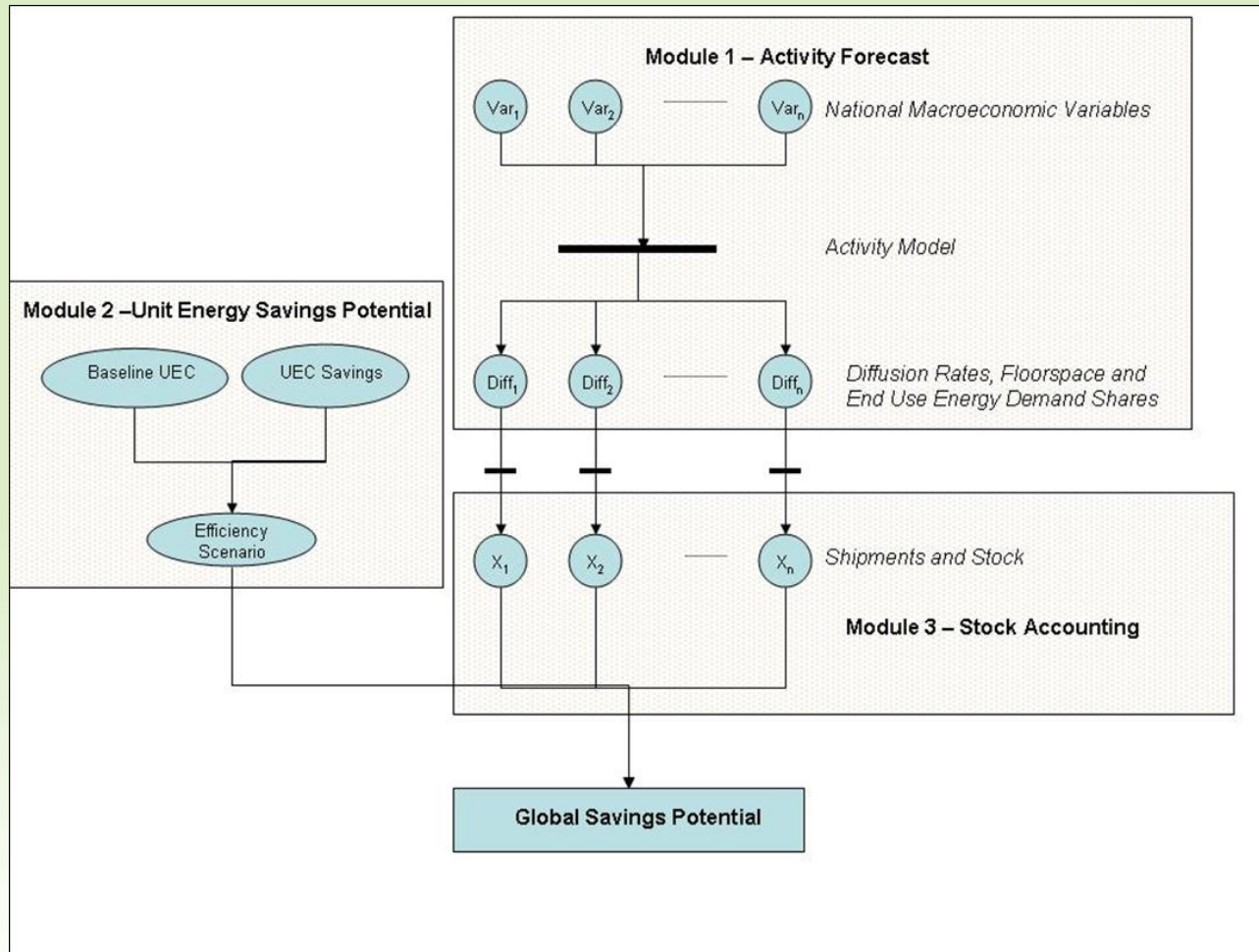
# BUENAS: Origin and History

## Activities Summary:

- **BUENAS covers 12 “countries” individually.**
- **Countries currently included in BUENAS are: Australia, Brazil, Canada, European Union, India, Indonesia, Japan, Republic of Korea, Mexico, Russia, South Africa and the United States.**
- **Chinese appliance energy demand and efficiency potential has also been modeled in detail by LBNL. This model is a component of the China 2050 model, which includes all energy demand sectors.**
- **The China appliance model (including industrial motors and distribution transformers) is currently being adapted to BUENAS and will be an integrated part of the model in the next version.**

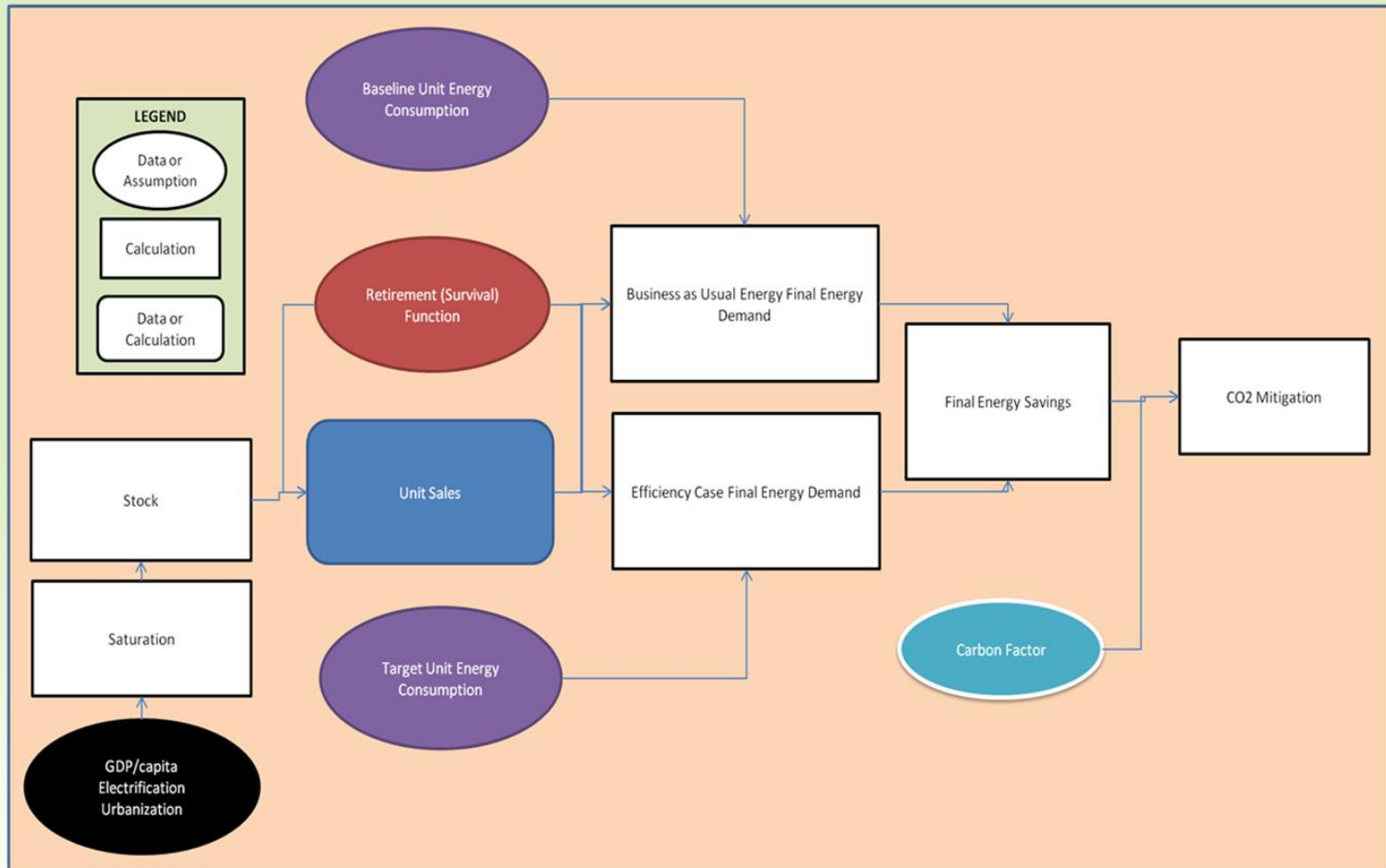
# BUENAS: Bottom-up Approach

## Modular Analysis Structure:



# BUENAS: Bottom-up Approach

## Model Flow Chart:



# BUENAS: Bottom-up Approach

## BUENAS Global Energy Demand Coverage:

- According to IEA data on total energy demand in 2005, the countries covered account for 62% of global energy demand. With China incorporated into the model, coverage is 77%.

Region	% Energy	Country	% Energy
Pacific OECD	8%	Australia	1.1%
		Japan	4.6%
		Korea	1.9%
North America	23%	United States	20.5%
		Canada	2.4%
Western + Eastern Europe	17%	European Union	15.6%
Former Soviet Union	9%	Russia	5.7%
Latin America	6%	Mexico	1.5%
		Brazil	1.8%
Sub-Saharan Africa	3%	South Africa	1.1%
Middle East + No. Africa	5%	-	-
Centrally-Planned Asia	16%	China	15.0%
South Asia - Other Pacific Asia	9%	India	4.7%
		Indonesia	1.6%
<b>Total</b>	<b>96%</b>	<b>Total without China</b>	<b>62%</b>
		<b>Total including China</b>	<b>77%</b>



# BUENAS: Bottom-up Approach

## BUENAS End-use Coverage:

BUENAS covers most major end-uses generally covered by Energy Efficiency Standards and Labeling (EES&L) programs around the world:

- **Residential Sector:** Air Conditioning, Cooking + Dishwashing, Fans, Lighting, Refrigeration, Space Heating, Standby, Televisions, Water Heating and Laundry
- **Commercial Building Sector:** Air Conditioning, Lighting, Refrigeration, Space Heating and Laundry
- **Industrial Sector:** Electric Motors and Distribution Transformers

The end-uses covered are estimated to include over 80% of the residential and commercial building sectors.

# BUENAS: Bottom-up Approach

## BUENAS Equations:

### 1. Energy Demand:

$$\text{Energy} = \frac{\text{Activity} \times \text{Intensity}}{\text{Efficiency}}$$

### 2. Energy Savings:

$$\Delta E(y) = E_{BAU}(y) - E_{EFF}(y)$$

### 3. Emissions Mitigation:

$$\Delta CO_2(y) = \Delta E(y) \times f_c(y)$$

$\Delta CO_2(y)$  = CO<sub>2</sub> mitigation in year  $y$

$\Delta E(y)$  = Final Energy Savings in year  $y$

$f_c$  = carbon conversion factor (kg/kWh or kg/GJ) in year  $y$

# **BUENAS: Bottom-up Approach**

## **Notes Regarding BUENAS Developments:**

- **The original development of BUENAS commissioned by CLASP was to provide a more precise estimate of the potential impacts of EES&L programs worldwide.**
- **The main objective of the development and improvement of BUENAS is to provide the most accurate assessment possible of energy savings and greenhouse gas emissions reductions.**
- **The model is needed primarily as a multi-country planning tool for CLASP, and to examine the potential for efficiency improvements.**
- **Until the development of BUENAS, rough estimates of the global potential of EES&L programs are typically based on a percentage savings of residential and commercial energy use.**

# BUENAS: Past and Current Applications

**BUENAS has been used for both Estimating EES&L Potential as well as for Planning and Prioritization applications**

- **2007-2008:** Commissioned by METI Japan to significantly improve previous estimates of worldwide potential of S&L
- **2008:** Adopted as a planning tool for Best Practice Network for Appliances, Lighting and Equipment
- **2009:** Analysis used for a comparison with national program plans in China
- **2010:** Used for priority-setting and impacts evaluation for Chile, Mexico, and Vietnam
- **2010 – 2011:** Used for tracking of S&L activities to date and in progress.

# **BUENAS: Past and Current Applications**

## **Notes Regarding BUENAS Applications (Cont'd):**

- **In 2008, BUENAS was able to produce a much more detailed global estimate of the savings potential, bringing attention to the value of EES&L policies globally**
- **BUENAS was also able to rank the potential impacts from EES&L policies among various countries or regions and among various energy-consuming products in 2008**
- **Beginning in 2010, BUENAS has been used to support the activities of the Super-Efficient Appliance Deployment project (SEAD)**
- **A main use of BUENAS within SEAD is to provide analysis of the remaining potential impacts of appliance efficiency program.**

# BUENAS: Past and Current Applications

## Notes Regarding BUENAS Applications (Cont'd):

- **BUENAS team provided SEAD with preliminary estimates in preparation for CEM I in July of 2010.**
- **BUENAS participation was ramped up in order to provide savings results for CEM 2, including:**
  - Part I – Standards implemented, announced or in progress 2010-2011
  - Part II – Potential standards in ‘best practice’ scenario
- **BUENAS-LEAP Version III – As a result of SEAD participation, BUENAS now includes: Australia, Brazil, Canada, EU, India, Indonesia, Japan, Korea, Mexico, Russia South Africa and the United States**

# BUENAS: Past and Current Applications

## Sample BUENAS Results: Estimating Impacts of Energy and Emissions Savings in 2030 for MEPS since January 2010

Category	Quantity	Unit	Australia	Canada	EU	Korea	Mexico	US	Total
1. Implemented	Electricity	TWh	1.9	1.9	56.0	1.7	0.0	197.1	259
	Gas	PJ						6.3	6
	CO <sub>2</sub>	mt	1.4	0.4	18.8	0.7	0.0	112.7	134
2. Announced	Electricity	TWh	0.0	7.5	21.8	0.0	0.4	0.8	30
	Gas	PJ	0.0	20.3	0.0	0.0	67.4	44.2	132
	CO <sub>2</sub>	mt	0.0	1.6	7.3	0.0	4.0	8.0	21
3. In Progress	Electricity	TWh		0.0	74.3	0.0	3.2	22.9	100
	Gas	PJ	6.4	0.0	204.0	0.0	0.0	1.1	211
	CO <sub>2</sub>	mt	0.4		40.0		2.1	21.2	64
Total	Electricity	TWh	1.9	9.3	152.1	1.7	3.6	220.7	389
	Gas	PJ	6.4	20.3	204.0	0.0	67.4	51.6	350
	CO <sub>2</sub>	mt	1.8	1.9	66.2	0.7	6.1	141.9	219

# BUENAS: Past and Current Applications

## Sample BUENAS Results: Estimating Potential of Energy and Emissions Savings in 2030 (Best Practice Case)

Sector	End Use	Part II		
		Electricity TWh	Gas PJ	CO <sub>2</sub> mt
Residential	Air Conditioning	114.0		52.0
	Cooking + Dishwashing	0.0		3.8
	Fans	77.1		53.7
	Lighting	110.5		55.3
	Refrigerators & Freezers	117.7		56.5
	Space Heating	0.2	133.9	38.1
	Standby	135.1		92.9
	Television	12.6		6.4
	Laundry	30.6		19.5
	Water Heating	133.3	119.2	98.4
	Commercial	Lighting	322.2	
Refrigeration		90.0		39.1
Air Conditioning		198.0		87.7
Space Heating		0.0		0.0
Industry	Distribution Transformers	82.1		141.0
	Motors	159.9		96.6
	<b>Total</b>	<b>1583</b>	<b>253</b>	<b>988</b>



# BUENAS: Recent Enhancements

In early 2010 BUENAS was ported to LEAP (Long Range Energy Alternatives Planning System) to improve the following areas:

- **Approach** – LEAP is a versatile energy accounting framework allowing a high level of detail and sophisticated modeling in a user friendly environment.
- **Accessibility** – LEAP is downloadable for use with a moderate license fee (waived for developing countries)
- **Collaboration** – BUENAS/LEAP is a transparent, shareable model that can be refined and modified by users an ongoing way.

**LEAP was developed by Stockholm Environment Institute (SEI).**

# **BUENAS: Recent Enhancements**

**As a part of its commitment to BUENAS, CLASP conducted an internal review and identified a number of potential and needed enhancement areas for BUENAS, including:**

- **Detailed documentation**
- **Peer review**
- **Development of a quality assurance approach and process for input data**
- **Wider user base**

# **BUENAS: Future Directions**

**CLASP's current plan and support for BUENAS include:**

## **1. Further develop BUENAS:**

- **Develop and implement a QC/QA process to insure that BUENAS meets its design specifications**
- **Improve model to emphasize more detail and accuracy**

## **2. Build internal expertise:**

- **Develop in-house expertise with BUENAS in order to provide support for the development of scenarios, collect and assemble data, and explore country-specific scenarios**

# **BUENAS: Future Directions**

**CLASP's current plan and support for BUENAS include (cont'd):**

**3. Make BUENAS accessible to internal and external use and collaboration (est. 4Q12):**

- **Make program available to others who want to conduct their own analyses.**

**Thank you!**  
**शुक्रिया!**

**Questions/Comments:**  
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# Residential Sector

## Activity – Appliance Ownership Rate per Household

- Modeled using external sales and stock forecasts for U.S. and Europe
- Modeled econometrically for India, China and Latin America

## Intensity – Annual Unit Energy Consumption per appliance

- Varies according to technology type, capacity (size)
- Depends on baseline efficiency in BAU. Scenarios created by alternative efficiency forecast.
- Climate dependency for fans and air conditioners.

Stock Accounting- Sales determined by increase in households, ownership rates, replacements. Combined with marginal intensity to give stock energy.

# Commercial Sector

## Activity – Appliance Ownership Rate per Household

- Floor space modeled econometrically according to GDP per capita
- Penetration of equipment (Watts per m<sup>2</sup>) driven by GDP per capita, climate (space cooling)
- Floor space total not divided by building type

## Intensity – Annual Unit Energy Consumption per appliance

- Lighting from use hours and efficiency
- Space cooling from climate dependency (CDD)
- Savings calculated from percentage efficiency improvement

Stock Accounting- Sales not modeled directly – turnover of installed equipment (in m<sup>2</sup>) according to equipment lifetimes.

# Electric Motors

## Activity – Industrial Electricity Growth

- Sales forecast only available for EU. For other countries, modeled as industrial electricity demand.

## Intensity – Annual Unit Energy Consumption per appliance

- Average capacity in category, use hours and load factor taken from EU studies
- Baseline efficiency estimated according to standards and labeling programs currently in place, and market share data.
- High efficiency scenarios from international best practice or other policy scenario (EU).

Stock Accounting- Sales used directly for EU only – turnover of installed equipment (in TWh) according to equipment lifetimes.



# End Use Intensity - Module 2

## Residential Buildings

- Equipment Baseline Unit Energy Consumption from published sources or data gathered from program data
- Time dependent UEC for air conditioners (usage) & TVs (technology)
- Climate dependent UEC for space heating & cooling + water heating
- UECs interpolated over regions where specific data not available

## Commercial Buildings

- Intensity modeled as a function of economic development (GDP/cap)

## Industrial Motors

- Constant fraction of industrial electricity demand

## PPT and BUENAS Comparison:

- **The PPT covers over 40 equipment types in all sectors and includes electric and fuel consuming equipment, as well as vehicles.**
- **BUENAS model covers fewer end uses for India, but could be expanded.**
- **The BUENAS framework includes several scenarios, all of which could be applicable to the Indian context :**
  - *Recent Achievements* (retrospective),
  - *Best Practice*,
  - *Cost Effective Potential*,
  - *Best Available Technologies*

## PPT and BUENAS Comparison:

- **There is some overlap in the methodology used in the PPT and in BUENAS.**
- **This commonality of methodology was enhanced by CLASP/LBNLs review of the PPT in 2010.**
- **The advantage of the *PPT* is in its comprehensiveness. The tool relies heavily on assumptions of market trends and estimates of energy improvement potential, and thereby provides a transparent evaluation of potential impacts for a wide range of equipment.**
- **BUENAS covers fewer end uses, but is more systematic in its approach, particularly in the area of equipment stock forecasting and efficiency improvement potential.**

## PPT and BUENAS Comparison:

- **BUENAS** benefits significantly from its use as an international tool, drawing on a database of technologies and international best practices and allowing direct comparison to a wide range of end uses and targets.
- Use of **BUENAS** as a planning tool would provide a means of not only prioritization based on greenhouse gas mitigation, but also *ex post* evaluation of program impacts and evaluation of financial impacts.

Parameter	PPT	BUENAS
Activity (sales and stock) Forecasting	Uses current (2007) annual sales and projected sales growth rates.	Uses either sales forecasts or household ownership rate forecasts. Calibrated according to population, household size forecast. Commercial equipment forecast according to commercial floor space projection. Industrial equipment forecast according to industrial GDP value added.
Outputs	2030 energy savings and emissions reductions.	Annual energy savings and emissions through 2030. Net present value of consumer financial impacts.
Unit Energy Consumption	Estimated wattage times annual hours of use.	International database of baseline annual unit energy consumption
Efficiency Improvement Potential	Estimate	Based on international best practices, cost-effective potential or best available technology (3 scenarios)
Coverage	16 residential appliances, 20 consumer electronics and office equipment products, 11 commercial and other products	Currently 9 products for India
Cost Benefit Evaluation	None	Targets defined according to cost-effective efficiency, consumer net present value as output
Impacts Perspective	Prospective Only	Retrospective and Prospective