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Implementing the Energy Conservation Building Code: Toolkit for Smart Cities

November 2016

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U.S. DEPARTMENT OF ENERGY

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Acronyms and Abbreviations

AP	Andhra Pradesh
BEE	Indian Bureau of Energy Efficiency
DCR	Development Control Regulation
ECBC	Energy Conservation Building Code
GIFT City	Gujarat International Finance Tec-City
PNNL	Pacific Northwest National Laboratory
USAID	U.S. Agency for International Development
VUDA	Visakhapatnam Urban Development Authority

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1.0 Introduction

India is developing rapidly with growing income and increasing urbanization. This growth reinforces the need to improve energy efficiency and increase sustainable development, especially in the buildings sector. Currently, buildings account for 33 percent of the total energy consumption in India [1]. The commercial floor space in India is estimated to reach 2 billion m^2 by 2030, representing a 66 percent increase over 20 years [2]. Building energy use in India is likely to grow given socio-economic trends. Recognizing a huge potential for energy savings in new construction of commercial buildings, India launched the Energy Conservation Building Code (ECBC) in 2007. ECBC sets requirements for building elements that impact building energy use. The U.S. Department of Energy and its Pacific Northwest National Laboratory (PNNL) have been helping India facilitate ECBC implementation for years and have made significant progress at the national and state levels.

In 2015, the Government of India launched the Smart Cities initiative, which focuses on sustainable and inclusive development and creating replicable models to serve as inspiration for other cities. Indian Smart Cities feature energy-efficient and green buildings, smart waste and water management, smart transportation, and other infrastructure elements that contribute to a sustainable and clean environment and a better quality of life for the city's citizens [3].

Implementing ECBC in Smart Cities would benefit both the promotion of building energy codes and the development of Smart Cities. Regarding building codes, although ECBC is generally adopted at the state level, it takes effect through local building by-laws. Urban local bodies enforce building codes. Therefore, the key nexus of ECBC implementation lies in cities. Smart Cities as leading city models could pioneer implementation of ECBC and set examples for other cities. The mission of Smart Cities requires that 80 percent of buildings in a Smart City be energy efficient and green [3]. Moreover, because of the interlinking between the buildings sector and other aspects of a city, ECBC, through the city's long-term planning process, also benefits the urban environment, power sector, city economy, and water management, all of which are critical components of a Smart City. Therefore, implementing ECBC in Smart Cities could improve both the buildings sector and other city features, thus significantly facilitating the fulfilment of Smart City goals.

Implementing ECBC in Smart Cities would benefit both the promotion of building energy codes and the development of Smart Cities. Regarding building codes, although ECBC is generally adopted at the state level, it takes effect through local building by-laws. Local governments, known as urban local bodies, enforce building codes. Therefore, the key nexus of ECBC implementation lies in cities. Smart Cities as leading city models could pioneer implementation of ECBC and set examples for other cities. The mission of Smart Cities requires that 80 percent of buildings in a Smart City be energy efficient and green [3]. Moreover, because of the interlinking between the buildings sector and other aspects of a city, ECBC, through the city's long-term planning process, also benefits the urban environment, power sector, city economy, and water management, all of which are critical components of a Smart City. Therefore, implementing ECBC in Smart Cities could improve both the buildings sector and other city features, thus significantly facilitating the fulfilment of Smart City goals.

This toolkit report provides an overview of needed and available resources to support ECBC implementation in cities. It aims to help Indian Smart Cities 1) better understand the importance of ECBC, 2) use available resources to adopt and implement ECBC, and 3) evaluate ECBC compliance.

2.0 Strategies in Smart Cities: Examples of Visakhapatnam and GIFT City

PNNL is working with two Smart Cities, Visakhapatnam and Gujarat International Finance Tec-City (GIFT City), to adopt and implement ECBC. This section summarizes the progress to date and offers key insights gained from our collaborative work with these two cities.

2.1 Visakhapatnam and Informing Stakeholders of the Benefits

Visakhapatnam is the largest city in terms of both area and population in the State of Andhra Pradesh (AP) [4]. It is one of the first 20 Smart Cities selected by the Government of India in January 2016 [5]. Ranked as the 10th wealthiest city in India [6], Visakhapatnam is also the financial center of Andhra Pradesh [7] and is expected to experience a construction boom. Adopting and implementing ECBC could help Visakhapatnam achieve its energy-efficiency goals as a Smart City.

The State of Andhra Pradesh tailored and adopted ECBC in 2014 (also known as AP ECBC). Compared with the original ECBC, AP ECBC has a star rating system where all buildings covered by the code are required to achieve at least "One Star," and there are incentives for buildings that receive ratings higher than One Star. In addition, ECBC is able to create considerable benefits. For example, according to the Indian Society of Heating, Refrigeration, and Air-conditioning Engineers Visakhapatnam Chapter, the potential energy savings and carbon emission reductions for commercial green buildings in Visakhapatnam is 15 kilowatt-hours/(ft^2*year) and 1,200 metric tons/year, respectively [8].

After two years of ECBC adoption by the state, however, Visakhapatnam has not yet adopted ECBC at the local level. There are not many energy-efficient buildings in Visakhapatnam. One of the barriers that hinder Visakhapatnam from seizing this energy savings opportunity is the cost of ECBC implementation: according to a survey by the Economist Intelligence Unit in 2012, three fourths of Indian buildings industry leaders believe that constructing energy efficient structures raises the cost by 15 percent or more, compared to traditional buildings. In fact, the incremental cost for Indian buildings was 16 to 17 percent in 2000 and only 4 percent in 2013 [9], as the domestic supply of efficient materials has grown.

We recommend two strategies to address this situation. First, it is fundamental to enhance people's awareness of ECBC and the benefits it provides. This effort also includes gaining stakeholders' support for code adoption. Cities could organize training sessions and provide informational materials introducing ECBC and documenting energy and economic savings to demonstrate the feasibility and benefits of ECBC. There are helpful materials on the basics of ECBC and real-world Indian examples that demonstrate ECBC benefits. (See Section 3 for details.) Second, it is critical for the local governments to develop a clear roadmap before launching actual ECBC implementation so stakeholders know what to expect. A stakeholder consultation process can strengthen implementation and make the roadmap more feasible. PNNL co-hosted stakeholder events with Indian state and local governments to discuss the roadmap (See Section 3 for sample agenda and presentations.).

In February 2016, PNNL and the Visakhapatnam Urban Development Authority (VUDA) co-hosted a one-day ECBC training and stakeholder event. We invited key stakeholders including local government officials, building developers, architects, engineers, and other building energy experts. At the event, presenters and panelists introduced ECBC and its benefits, shared international experience on building

code implementation, and discussed viable options for ECBC implementation in the city [10]. Following the event, PNNL drafted a report for VUDA with recommendations for developing a roadmap. The report includes strategies for capacity building, implementation roll-out for the public and commercial sectors, compliance enforcement, and incentive development [11].

2.2 GIFT City and Moving from Awareness to Action

As India's first Smart City, GIFT City is a rapidly developing central business district between Ahmedabad and Gandhinagar in the State of Gujarat [12]. With a master plan for 5.8 million m^2 of total built-up area, the estimated power demand for GIFT City is around 740 megawatts [13]. Sustainable development and energy efficiency are important components of GIFT City's planning and development. The GIFT City Development Control Regulation (DCR) requires that all buildings in GIFT City be certified with the Leadership in Energy and Environmental Design India [14], which in most cases would also be ECBC compliant. In addition, the city features a district cooling system with an estimated capacity of around 100,000 tons of refrigeration, which will help improve energy efficiency and reduce energy costs [15].

PNNL has been working with the State of Gujarat to prepare for adopting ECBC. Although GIFT City has not yet adopted ECBC, the environment is conducive to its implementation. Stakeholders in GIFT City are well aware of building energy efficiency, and the building approval process in GIFT City is straightforward because of its small size. GIFT City could be an exemplary model in ECBC implementation and could set an example for other cities to follow.

To set up the framework for ECBC implementation, the local governments needs to incorporate ECBC into local building by-laws. In GIFT City, this means incorporating ECBC into the DCR. At the national level, the Indian Ministry of Urban Development published model building by-laws that referenced ECBC. Local governments may refer to these by-laws when developing their own. (See Section 3 for details.) Implementing ECBC would then require the development of guidelines on how to enforce ECBC in the city and build enforcement capacity accordingly. This can include using third-party assessors, improving compliance software, constructing pilot buildings, and conducting training sessions targeting different stakeholder groups.

In February 2016, PNNL and the GIFT City Company Limited co-hosted an ECBC training and stakeholder meeting with the support of the Gujarat Energy Development Agency. Participants at the event presented examples from other states and cities that highlighted ECBC benefits, shared international experience on building code implementation, and discussed options for ECBC implementation guidelines for GIFT City. After the meeting, PNNL wrote detailed guidance for GIFT City on how to incorporate ECBC into its DCR. PNNL has also been working with GIFT City to assess a new building for ECBC compliance with the goal of turning it into a pilot ECBC-compliant building.

3.0 Tools for ECBC Adoption, Implementation, and Compliance in Smart Cities

Since launching ECBC in 2007, the Government of India with the help of domestic and international organizations has developed many useful resources and tools to facilitate ECBC implementation. This section reviews and summarizes existing materials developed by the Indian Bureau of Energy Efficiency (BEE), Shakti Foundation, Natural Resource Defense Fund, U.S. Agency for International Development's (USAID's) ECO-III Project, and U.S. Department of Energy's PNNL. We categorize the materials according to their purpose within the following stages of development: adoption, implementation, and compliance.

3.1 Adoption of ECBC in Smart Cities

Adopting ECBC at the local level is the first step in implementation. To adopt ECBC, a city needs to motivate stakeholders and get their buy-in on an ECBC roadmap. In addition, the city needs to incorporate ECBC into local building by-laws. Urban local bodies could use technical support throughout this process.

Table 1 – Resources for Code Adoption

Purpose	Tool	Stakeholders	Description and URL
Gain stakeholder support and build general capacity	Agenda templates for stakeholder meetings	Local government	PNNL organized state- and local-level stakeholder meetings to introduce ECBC and gain stakeholders' support. Appendix A provides an agenda template for stakeholder meeting on ECBC introduction.
	Training materials for conceptual understanding	Local government Building owners Building developers Architects and engineers Building industry professionals	USAID and BEE developed ECBC training materials to introduce ECBC basics. Training modules introducing ECBC requirements; see http://eco3.org/wp-content/plugins/downloads-manager/upload/ECBC_Training_Modules_1_to_8.pdf, Module 1 & 2. PNNL developed training material for local code officials, which provides a brief overview of ECBC and its benefits; see http://www.globalchange.umd.edu/wp-content/uploads/2016/07/ECBC-Introduction.pdf.
	ECBC benefit analysis	Local government Building owners Building developers	PNNL conducted a benefit analysis for ECBC in Gujarat to show the potential for energy and economic savings in comparison with other building energy

		Building industry professionals	programs; see presentation at http://www.globalchange.umd.edu/wp-content/uploads/2016/07/Gujarat-Benefit-Analysis.pdf.[1]
	Pilot building case studies	Local government Building owners Building developers Architects and engineers Building industry professionals	Malaviya National Institute of Technology wrote a case study of its on-campus ECBC pilot building; see https://cleanenergysolutions.org/sites/default/files/documents/ecbc_released_version.pdf. PNNL developed a brochure on the pilot building; see http://www.globalchange.umd.edu/wp-content/uploads/2016/07/Jaipur-Pilot-Building-Brochure.pdf.
	City-level case studies	Local government	City-level case studies could help local governments have a big-picture view of how ECBC takes effect and interacts with other dimensions of the city. Natural Resources Defense Council's report Analyzes and offers recommendations for the Hyderabad buildings sector; see https://www.nrdc.org/sites/default/files/efficiencynewheights.pdf. A state-level ECBC progress report for Rajasthan by PNNL is also available; see http://www.globalchange.umd.edu/wp-content/uploads/2016/07/Rajasthan-Impact-Assessment-Report.pdf.
Incorporate ECBC into building by-laws	Model building by-laws to incorporate ECBC	Local government	Indian Ministry of Urban Development published 2016 model building by-laws to reference ECBC as a requirement for certain types of buildings. Local governments could use them as a template for their building by-laws and may extend requirements on the basis of it. See 2016 model building by-laws at http://www.indiaenvironmentportal.org.in/files/file/MODEL%20BUILDING%20BYE%20LAWS-2016.pdf.

[1] For more technical analysis of ECBC benefits, check http://www.sciencedirect.com/science/article/pii/S037877881200494X and http://www.sciencedirect.com/science/article/pii/S0378778812006068 for research papers on the topic. PNNL authored a journal article based on the ECBC benefit analysis in Gujarat, which will be available upon release.

3.2 Implementation of ECBC in Smart Cities

Implementation is where ECBC makes its impact. To facilitate implementation, the city needs to develop implementation strategies, establish institutions, build enforcement and compliance capacity, and provide compliance incentives. Useful resources and tools can smooth this process.

Table 2 – Resources for Code Implementation

Purpose	Tool	Stakeholders	Description and URL
Develop implementation strategies	ECBC roadmaps	Local government	An ECBC roadmap serves as a reference for local governments to plan the ECBC implementation process. See sample roadmaps published by BEE at http://eecbindia.com/?page_id=115. PNNL developed a roadmap for Rajasthan; see http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21054.pdf.
	Agenda and presentation templates for stakeholder meetings on implementation options	Local government	PNNL organized stakeholder events in states and cities to discuss implementation options with stakeholders. Agenda template for stakeholder meeting on implementation guidelines is available (see Appendix B).
	Implementation guidelines	Local government	In addition to an ECBC roadmap, it is critical for cities to have specific guidelines with a focus on implementation. This will facilitate concrete ECBC actions. The Malaviya National Institute of Technology Jaipur co-authored a recommendation paper with PNNL on integrating third parties into building permitting process. The paper examines existing ECBC implementation mechanisms in Rajasthan and recommended detailed implementation guidelines for using third parties. See http://www.globalchange.umd.edu/wp-content/uploads/2016/07/Recommendation-on-Integrating-Third-Parties-in-Building-Permitting-Process.pdf.
Establish institutions	White paper on third party	Local government	Cities can use a third-party assessor system to rapidly

Purpose	Tool	Stakeholders	Description and URL
	recommendation		build capacity, especially at the initial stage of code implementation. PNNL developed a white paper summarizing international use of third parties in building code enforcement and provided specific recommendations. See http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22155.pdf.
	Recommendations on establishing ECBC cells; ECBC cell experience in states and cities	Local government	ECBC implementation needs coordination among various state and local government departments. Having an ECBC cell, an organized administrative unit under the local government in support of ECBC, can significantly ease the process and integrate resources needed for ECBC implementation. Some states and cities have already established ECBC cells, including Chhattisgarh and Karnataka. PNNL is recommending that Visakhapatnam create an ECBC cell and is developing specific recommendations in terms of roles and staff of the cell and how it could help adopt ECBC. Indian Bureau of Energy Efficiency wrote Invitations for Expression of Interest to hire an agency to build capacity via an ECBC cell in several states; see Karnataka example at http://www.undp.org/content/dam/india/docs/procurement/EOI_ECBC_Cell_KN.pdf.
Build enforcement capacity	BEE master training program	Local government Architects and engineers	Through the program, building professionals can receive trainings and certification as ECBC master trainers to help facilitate future training and build capacity. See program introduction and eligibility at http://eecbindia.com/?page_id=109.
	Training materials in building physics and compliance checking procedures	Local government Architects and engineers Building owners Building developers	USAID and BEE developed ECBC training materials to close capacity gaps in compliance checking procedures and building physics. See http://eco3.org/wp-content/plugins/downloads-ma

Purpose	Tool	Stakeholders	Description and URL
		Building industry professionals	nager/upload/ECBC_Training_Modules_1_to_8.pdf, Module 3-8, and http://eco3.org/wp-content/plugins/downloads-manager/upload/ECBC_Training_Module_9-Building_Physics.pdf for building physics.
Build compliance capacity	ECOnirman	Architects and engineers Building developers Building industry professionals	People in India use ECOnirman as ECBC simulation software. PNNL provided technical assistance to improve it. See user manuals at http://www.eco3.org/ECOnirman-Prescriptive/ (prescriptive) and http://www.eco3.org/ECOnirman-WBP (whole-building performance).
	Training materials on the use of simulation software	Architects and engineers Building developers Building industry professionals	See training materials at http://eco3.org/wp-content/plugins/downloads-manager/upload/ECBC_Training_Modules_1_to_8.pdf, Module 8, "Building Energy Simulation".
	Report on review and revision of "Schedule of Rates" based on ECBC requirements	Local government	The Shakti Foundation prepared a recommendation report to update the Schedule of Rates based on ECBC requirements for the Central Public Works Department. The Schedule of Rates lists the products allowed for public building procurement. See report at http://shaktifoundation.in/wp-content/uploads/2014/02/revision%20of%20cpwd%20specifications%20and%20schedule%20of%20rates%20for%20ecbc%20compliance.pdf.
	Compliance checklist	Architects and engineers Building developers Building industry professionals	See ECBC checklist at http://eco3.org/wp-content/plugins/downloads-manager/upload/ECBC_Training_Modules_1_to_8.pdf, Module 8, "ECBC Compliance Process" and "Energy Simulation Considerations".
	Online building approval system with ECBC integration	Local government	The State of Telangana is developing an online building approval system that is quick and easy to use. By integrating ECBC into the system and replicating the system in urban local bodies, code implementation will expand rapidly. See an introduction to the online building approval system at https://www.nrdc.org/sites/default/files/better-future-energy-saving-building-code-hyderabad.pdf.

Purpose	Tool	Stakeholders	Description and URL
Provide incentives for compliance	Report on incentives for energy-efficient buildings in India	Local government Building owners Building developers Building industry professionals	The Natural Resources Defense Council report summarizes incentives for energy-efficient buildings across India. See report at https://www.nrdc.org/sites/default/files/energy-efficient-construction-incentives-IB.pdf.

3.3 Compliance Evaluation of ECBC in Smart Cities

After Smart Cities adopt and implement the code, compliance evaluation can demonstrate the effectiveness of code enforcement and, therefore, provide feedback to improve building energy codes and implementation mechanisms. Currently, compliance evaluation gets less attention in India than code adoption and implementation. Thus, there is space for improvement in evaluation and a great need for technical assistance.

Table 3 – Resources for Compliance Evaluation

Purpose	Tool	Stakeholders	Description and URL
Understand the importance and options of compliance evaluation	Compliance evaluation white paper	Local government Building owners Building developers	PNNL prepared white paper for India. The white paper highlights the importance of compliance evaluation, shares international experience, and provides recommendations for India; see white paper at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23217.pdf.

4.0 Critical Elements for Improving ECBC Implementation in Smart Cities

ECBC will have profound impacts on building energy efficiency when more cities implement it; the promotion of Indian Smart Cities is a great opportunity to scale up ECBC implementation. Although cities are different from each other, it is helpful to learn from the experience in Visakhapatnam and GIFT City and replicate the lessons learned to other cities across India.

- **Strategies to implement ECBC need to be city specific**

  Cities are different in scale, development, and awareness and capacity for ECBC implementation. All these differences account for the outcome of ECBC implementation. As there is no one perfect plan for all cities, each city will need to assess their own situation and develop city-specific strategies to maximize the impact of ECBC.

  Our experience in Visakhapatnam and GIFT City demonstrate how different cities utilize different strategies for ECBC implementation. Although the State of Andhra Pradesh announced its adoption of ECBC two years ago, Visakhapatnam as a major city in the state has not yet adopted it. Therefore, the first step for ECBC implementation is to raise people's awareness and gain stakeholders' support. People in GIFT City are more familiar with ECBC and are supportive for its implementation, so the focus is to build on awareness and roll out actions for enforcement.

- **Integrate ECBC into Smart City plan**

  The buildings sector interacts with many other aspects of city development, such as the power sector and water management. As a result, coordinated efforts across various sectors are critical to the successful implementation of ECBC in cities.

  The Smart City Challenge requires each participating city to submit a proposal for competition, and the winners receive funding for the realization of their proposals. Such competition is a great opportunity for candidate cities to develop pan-city proposals with integration of ECBC.

- **Develop critical elements of integrating ECBC**

  ECBC takes effect in cities following several key elements, as below:

  1) Gaining stakeholder support for ECBC implementation;
  2) Enabling registration on building compliance;
  3) Developing city-specific implementation roadmaps;
  4) Integrating efforts in the buildings sector and in other city aspects;
  5) Supporting training activities to increase capacity;
  6) Expanding the market for energy efficiency products;
  7) Building a system to test, rate, and label building products;
  8) Improving tools and resources for ECBC implementation such as ECOnirman; and
  9) Conducting compliance evaluation for better implementation and broader impacts.

5.0 Conclusion

Both ECBC and the Smart Cities initiative serve for better development of the city. First, ECBC helps improve building energy efficiency, which is an important component of Smart City development. Second, ECBC improves the performance of other city sectors via their interaction with the buildings sector. Third, ECBC implementation generates economic savings from better building performance, which could serve as investments to improve city infrastructures. In addition, code implementation also increases the viability of related markets such as the market for energy efficiency products, and as a result facilitates the development of city's economy. Lastly, by providing a more efficient and comfortable building environment, ECBC makes the city a better place for the citizens to live in, which is the ultimate goal of a Smart City.

A key element for desired impact of ECBC is implementation at the local level, which is the level primarily responsible for its adoption, enforcement, and compliance evaluation. Resources and tools are available for stakeholders to use during all phases of ECBC implementation at the local level.

In addition to existing resources and tools, there are opportunities for improvement. For example, although there are case studies of pilot buildings and state-level ECBC implementation reports, there are rarely city-level examples for local implementation to follow, and ECBC implementation in cities may differ significantly from state implementation and pilot building construction. In the future, our experience in Visakhapatnam and GIFT City may be able to serve as city-level examples. Cities also need sample implementation guidelines and experience sharing in ECBC cells, as they are both necessary components of successful implementation. Meanwhile, ECOnirman is becoming more widely used in India and should be improving over time as more buildings are complying with the code and technology improves. At the same time, cities could encourage the use of diverse simulation tools to better ensure compliance. Finally, compliance evaluation needs more attention as it is critical to improving codes and implementation mechanisms. Cities need more resources in this area to understand the importance of compliance evaluation and useful approaches to conducting it. With the help of more well-developed resources and tools, Smart Cities could better take the lead in implementing ECBC and facilitate its scale-up in more cities across India.

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Appendix A Agenda Template for Stakeholder Meeting on ECBC Introduction

[city name] ECBC Stakeholder Event – [Location], [Date]

Time	Topic
30 min	Registration
10 min	Opening remarks – [local government official]
40 min	ECBC introduction (Codes 101), benefits and best practices in other Indian states and cities – [domestic building energy expert]
20 min	International experience on energy code implementation and enforcement – [international building energy expert]
10 min	Q & A
60 min	ECBC roadmap • Current status of ECBC in [city name] and need for assistance in the buildings sector of Smart City development – [local government official] (30 min) • Recommendations to amend building by-laws – [international building energy expert] (30 min)
60 min	Panel discussion (moderator: [local government official]) • Incorporating ECBC into local building by-laws • Incentive policies and other government support • Needs for capacity building and plans for third-party assessor system • Pilot building
10 min	Closing remarks – [international building energy expert]

Appendix B Agenda Template for Stakeholder Meeting on Implementation

[city name] ECBC Stakeholder Event – [location], [date]

Time	Topic
30 min	Registration
10 min	Opening remarks – [local government official]
35 min	Best practices in other Indian states and cities – [domestic building energy expert] • Presentation (30 min) • Q & A (5 min)
25 min	International experience on building code implementation in cities – [international building energy expert] • Presentation (20 min) • Q & A (5 min)
60 min	ECBC implementation guidelines • Current status of Green Buildings/ECBC in [city name] – [local government official] (30 min) • Recommendations on ECBC guidelines in [city name] – [international building energy expert] (30 min)
70 min	Panel discussion (moderator: [local government official]) • Key elements of ECBC guidelines • Necessary institutional set-up for ECBC implementation • Incentive program and other government support • Needs for capacity building • Pilot buildings
10 min	Closing remarks – [international building energy expert]

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