DRO PUBLICATION ISSUE 01 | APRIL 2024

Adaptive Reuse Framework

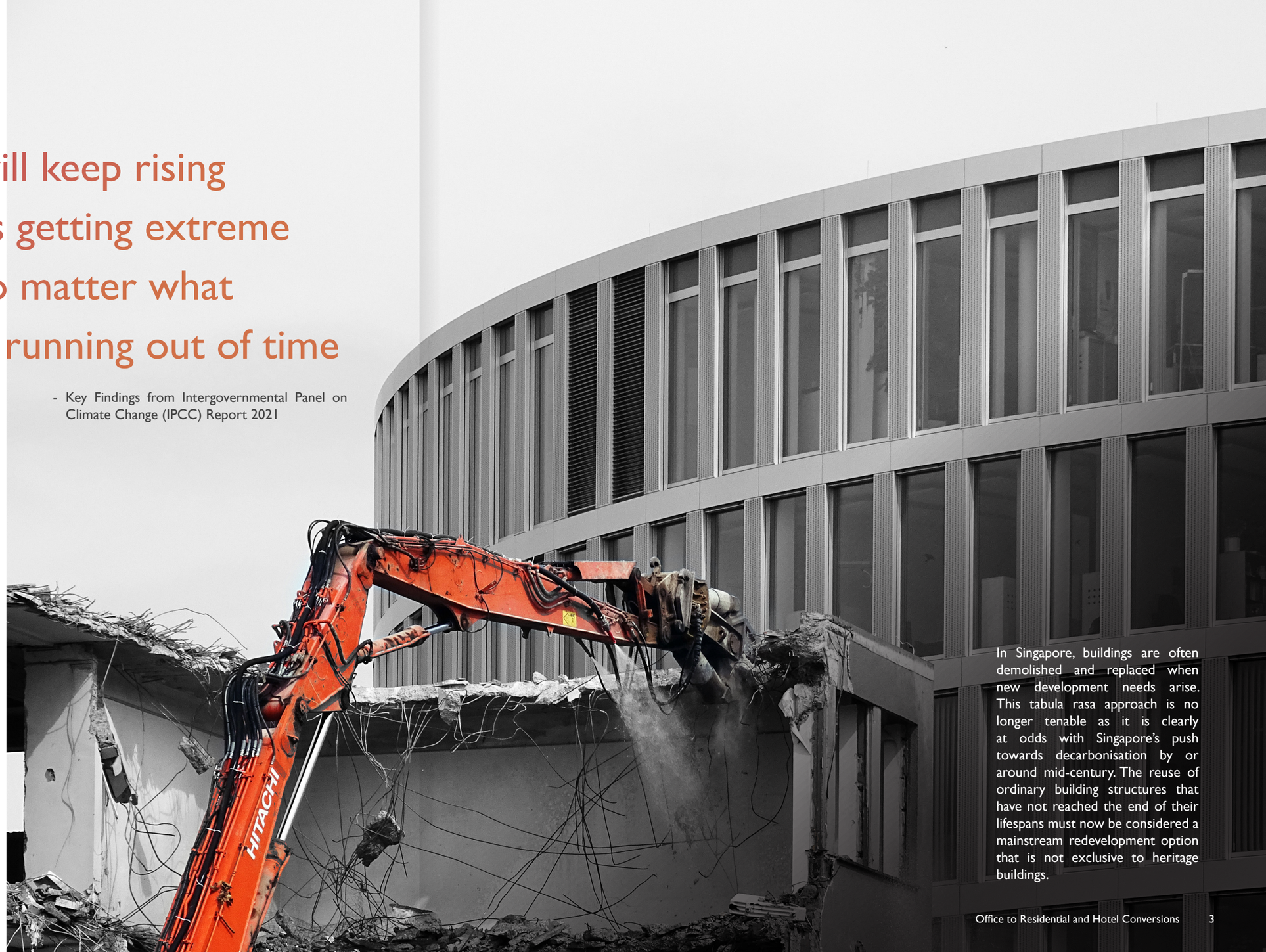
for Office to Residential and Hotel Conversions

CPG CORPORATION | DESIGN AND RESEARCH OFFICE

Temperatures will keep rising
Weather is getting extreme
Sea levels will rise no matter what
We are running out of time

- Key Findings from Intergovernmental Panel on Climate Change (IPCC) Report 2021

According to Architecture 2030, the construction sector accounts for 42% of annual global CO_2 emissions, of which 27% comes from building operations, and the remaining 15% from the embodied carbon of four common building materials – cement, iron, steel, and aluminium. While significant strides have been made in reducing operational carbon emissions from buildings, efforts to curb embodied carbon emissions have remained relatively stagnant. Meanwhile, development growth continues at a rapid pace, depleting dwindling material resources and adding to the world's mounting carbon debt.



In Singapore, buildings are often demolished and replaced when new development needs arise. This tabula rasa approach is no longer tenable as it is clearly at odds with Singapore's push towards decarbonisation by or around mid-century. The reuse of ordinary building structures that have not reached the end of their lifespans must now be considered a mainstream redevelopment option that is not exclusive to heritage buildings.

Buildings in Singapore have shorter lifespans due to rapid urban renewal, leading to higher embodied carbon emissions of 40% over a building's lifespan, compared to the global average of 30%.[1]

The starting point of our research was Singapore's Central Business District, which has undergone a rapid transformation from a single-use business district to a diverse mixed-use neighbourhood in recent years, with older office buildings being demolished to make way for new mixed-use developments. Few will argue with the impetus behind this change – besides creating vibrancy, mixed-use districts have proven to be more resilient for businesses during disruptive events such as pandemics and economic recessions, with a built-in flexibility to adapt to changing trends of use. However, in the face of worsening climate change, we must rethink the demolish-and-rebuild approach, which creates an outsized carbon footprint that cannot be ignored. This naturally leads to the question of converting office buildings to residential, hotel or mixed-use buildings. While such conversions have been successful in cities such as New York and Los Angeles, are they feasible in Singapore?

1. *Singapore Green Building Council. "Understanding Embodied Carbon." https://www.sgbc.sg/about-green-building/sgbc-embodied-carbon-pledge. (Last accessed 25 March 2024)*

In the face of rapidly worsening climate change, we must rethink the demolish-and-rebuild approach, which creates an outsized carbon footprint that cannot be ignored.

To assess the adaptive reuse potential of existing office buildings in the CBD, we conducted research into the configuration of high-rise office, residential and hotel buildings in Singapore to distill and quantify the factors that affect the feasibility of such conversions. The result is an evaluation tool that can be used to perform a high-level assessment of any given office building and score them for their conversion potential to residential or hotel use. This allows for easy benchmarking across different office buildings, enabling building owners and developers to understand where they stand in comparison to other buildings.

Are Office Conversions Feasible in Singapore?

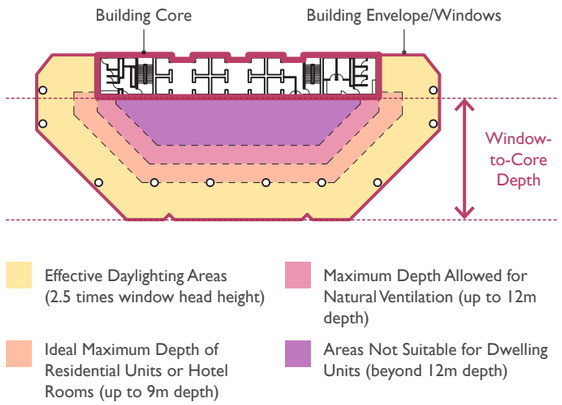
Key Considerations for Office to Residential and Hotel Conversions

Access to Daylight and Natural Ventilation

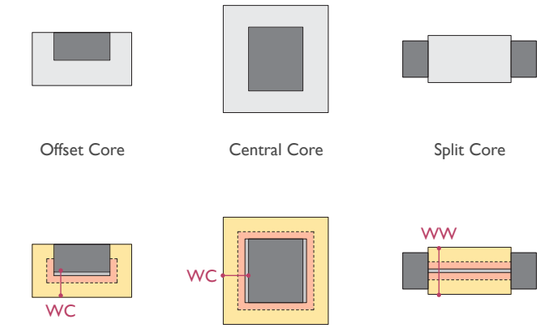
Office buildings are typically designed with large, column-free spaces to provide maximum flexibility for prospective tenants, and office floor plates tend to be "deep" because they are fully air-conditioned and do not need to rely on natural ventilation.

One of the key factors that determines the feasibility of an office to residential or hotel conversion is the core-to-window depth. This is especially so for residential conversions because BCA mandates that daylighting and ventilation must be provided for bedrooms and living rooms within a residential unit. In general, our research shows that the depths of the units or rooms should not exceed 9m to allow good access of natural ventilation and daylight.

Large office floor plates may have areas that are too deep for residential units and hotel rooms, resulting in unusable spaces that contribute to a low floor plate efficiency.



Effective Depths for Daylighting and Natural Ventilation



Types of Floor Plate Configuration and Ideal Depths

Fire Safety

In Singapore, fire safety requirements differ between office, high-rise residential and hotel uses, which have a great impact on the feasibility of office to residential and hotel conversions.

For residential buildings, it is mandatory for the common corridors, smoke free lobbies and exit staircases to be naturally ventilated under the Fire Code 2023. This requirement restricts the feasibility of office to residential conversions as the circulation areas of office buildings are often designed to be internalised and mechanically ventilated. In such cases, modifications to the existing floor plate will be required to provide natural ventilation. For hotel occupancy, common corridors can be mechanically ventilated or air- conditioned if they are pressurised.

The maximum allowable travel distances for offices are greater than those for residential and hotel occupancies. However, office floor plates seldom reach sizes that exceed the maximum travel distances required for residential and hotel occupancies. Besides, office spaces are typically designed with a higher occupant load compared to residential and hotel spaces based on code requirements. Hence, occupant load is generally not a limiting factor in office to residential or hotel conversions.

Other Considerations

Age of Building: When a building has clearly become obsolete, upgrading or redevelopment may be necessary. In such cases, the option of adaptive reuse should be considered.

Sense of Place: An adaptive reuse approach can help to preserve the character and identity of neighbourhood, reinforcing its sense of place by retaining familiar features of a building while transforming it to meet contemporary needs.

Architecturally Distinct Features: Buildings features that are regarded as architecturally distinct and exceptional should be retained if possible. These features may be in the form of specific spaces within the building, such as a well-used public atrium, or a building component such as the façade.

Building Envelope: An office building that is rebranded as a residential or hotel typically requires a fresh identity and image, and a new façade is often considered a must. Façade replacement may also be necessary for functional reasons, such as to provide natural ventilation for residential units, or to comply with new environmental sustainability standards pertaining to heat gain and energy consumption.

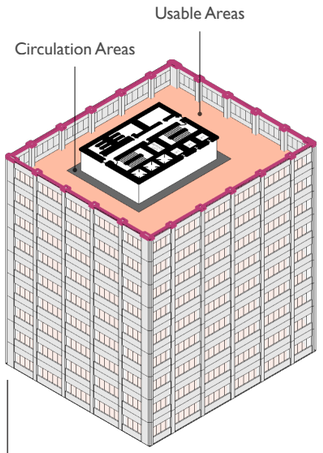
Increase in GFA: A common push factor for redevelopment is to take advantage of the increase in the maximum allowable GFA for a given site, which may have arisen due to changes in the Master Plan, or due to development incentives given by the government. The increase in GFA can be introduced through vertical or horizontal extensions of an existing building in an adaptive reuse project.

Office to Residential Facade Transformation for Tong Eng Building / *CPG Design and Research Office*

Floor Plate Modifications

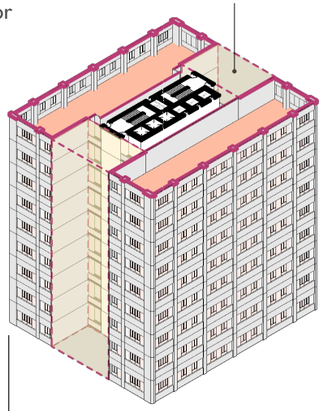
Not all existing office buildings are ideally configured for residential and hotel conversion as they were not designed for that purpose. However, some office buildings can be successfully converted for residential or hotel use with strategic modifications to the existing floor plates.

Before the adaptive reuse potential assessment matrix is applied, a given office floor plate will be prepared for subdivision into residential units or hotel rooms using the dimensional guidelines established in our research, and strategies to improve the floor plate configuration for access to daylighting and natural ventilation will be applied where required.



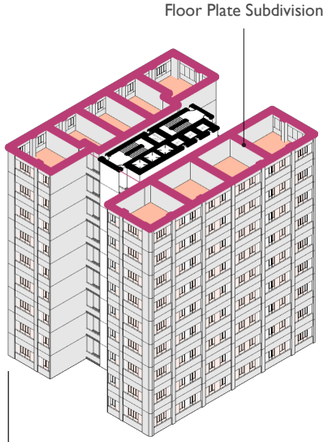
Step 1

Defining circulation and usable areas for residential units and hotel rooms based on the core configuration.



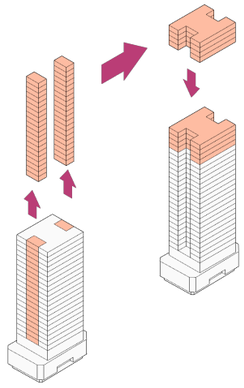
Step 2

Modifying existing floor plates to comply with regulatory requirements and to reduce non-usable areas.



Step 3

Subdividing usable areas into individual residential units or hotel rooms. Finetuning circulation areas to provide access into individual units or rooms.



Redistributing GFA

Demolished areas can be consolidated and redistributed by adding new floors on top of the building or reallocating the area within the site boundary. This can help to increase the number of residential units or hotel rooms within the development.

Adaptive Reuse Potential Assessment Matrix

The modified floor plans are assessed against a set of evaluation criteria. Criteria that have greater impact on construction costs and financial returns are assigned higher weightages.

For example, if the amount of floor plate modification is significant, the project becomes more costly, more time-consuming and less viable. Similarly, if the resulting floor plate efficiency falls below benchmark norms, the project becomes less viable. For hotel conversions, the number of keys that can be derived from the typical floor plates is introduced as an additional criterion because this directly affects the operating revenue of a hotel.

Office buildings are graded 'A' to 'D' based on the feasibility of their conversion to residential or hotel use.

Evaluation Criteria

- **Floor Area Demolished**
- **Floor Plate Efficiency**
- **Number of Keys (for Hotel only)**
- **Parking Provision**
- **Quality of Units / Rooms**

Grading

A The conversion is feasible as a standalone residential or hotel development without any floor plate modification.

B The conversion is mostly feasible as a standalone residential or hotel development. Some floor plate modifications may be required.

C The conversion is mostly not feasible as a standalone residential or hotel development. May be considered as part of a mixed-use development project.

D The conversion is not feasible as a standalone residential or hotel development. May be considered as a small part of a mixed-use development project.

> Our research revealed that hotel conversions far outperform residential conversions.

Our Findings

Six office buildings with various floor plate sizes and core configurations in the Central Area were used as test cases for developing our assessment matrix. The results showed that hotel conversions were significantly more viable, with 4 out of 6 buildings scoring an 'A'. Conversely, 5 out of 6 buildings scored 'C' or 'D' for when converted to residential use.

What makes office to hotel conversions so much more viable? Amongst the test cases, many did not require significant floor plate modifications. In addition, the target floor plate efficiency for hotels is not high, because hotel rooms are commonly laid out in a double loaded corridor configuration to maximise the number of keys. Hotel rooms are small compared to most residential units, so it is generally not too difficult to meet the target number of keys for a given building.

Office to residential conversions appear to be less feasible due to the mandatory requirement for the common corridors and exit staircases to be naturally ventilated in the Fire Code 2023. To achieve this, partial demolition of the existing floor plates was necessary in all the test cases. Our research showed that if the natural ventilation requirement could be relaxed for office to residential conversions, 3 out of 6 projects could become viable, with a score of 'A' or 'B'.

What about the embodied carbon savings?

The embodied carbon savings that may be obtained from reusing the building structure – including the foundation, columns, framing and floor slabs – in an adaptive reuse project is often significant as the structure can contribute up to 65%[2] of total embodied carbon of a new office building. The embodied carbon savings for a given building can be estimated based on the amount of building structure retained and reused in a conversion project by accounting for the carbon that will be emitted if a new building structure of equivalent area is constructed instead.

A one-way trip from Singapore to London by plane generates about **840kg of CO_2 per passenger**.[3]

The conversion of Prudential Tower to a hotel building would result in estimated **11,640 tons CO2e of embodied carbon savings**, equivalent to:

Carbon emitted by

13,800

One-Way Trips from Singapore to London per passenger by plane

2. *London Energy Transformation Initiative (LETI) Climate Emergency Design Guide, Jan 2020 edition, pp. 30.*
3. *Singapore Airlines. "The Singapore Airlines Group Carbon Offset Programme." https://carbonoffset.singaporeair.com.sg/. (Last accessed 25 March 2024)*

Office to Hotel Facade Transformation for Prudential Tower
/ CPG Design and Research Office

Office conversions are not necessarily more costly and time-consuming compared to building anew, especially when they are converted to hotels.

Construction Cost Implications

Office conversions can be less costly and save time compared to building anew if the original floor plate configuration is well-suited to its new use. Buildings that score well in the adaptive reuse potential assessment matrix can be converted to residential or hotel use without significant modifications to its structure and floor plate and meet the performance expectations of its new use. Cost savings can be significant as the building structure typically constitutes 20% to 30% of the total construction cost in high-rise buildings. The construction period can be shorter compared to building anew if minimal modifications to the existing building structure are required and if the amount of new structural works is small.

How can the Assessment Matrix be used in practice?

Stage 1

High-level Evaluation: Adaptive Reuse Potential Assessment Matrix

The input required to perform a high-level evaluation of a building using the assessment matrix comprises the typical office floor plan, the number of typical floors, the existing GFA and the existing number of car park lots – information that is readily available to a building owner or developer. The outcome is a grade score that indicates its conversion potential to a residential or hotel building.

If the building scores a 'C' or 'D', it is not likely to be suitable for conversion. However, a mixed-use development where the residential or hotel component occupies a portion of the tower may be considered.

Input Required for Assessment Matrix

Typical Office Floor Plan

Number of Typical Floors

Existing GFA

Existing Number of Car Park Lots

Stage 2

Planning Study and Test Fits

A building that scores an 'A' or 'B' under the assessment matrix is likely to viable for conversion to residential or hotel use. The next stage is to perform test fits based on a more specific brief from the developer, which may include unit or room sizes, other design requirements and key building performance metrics.

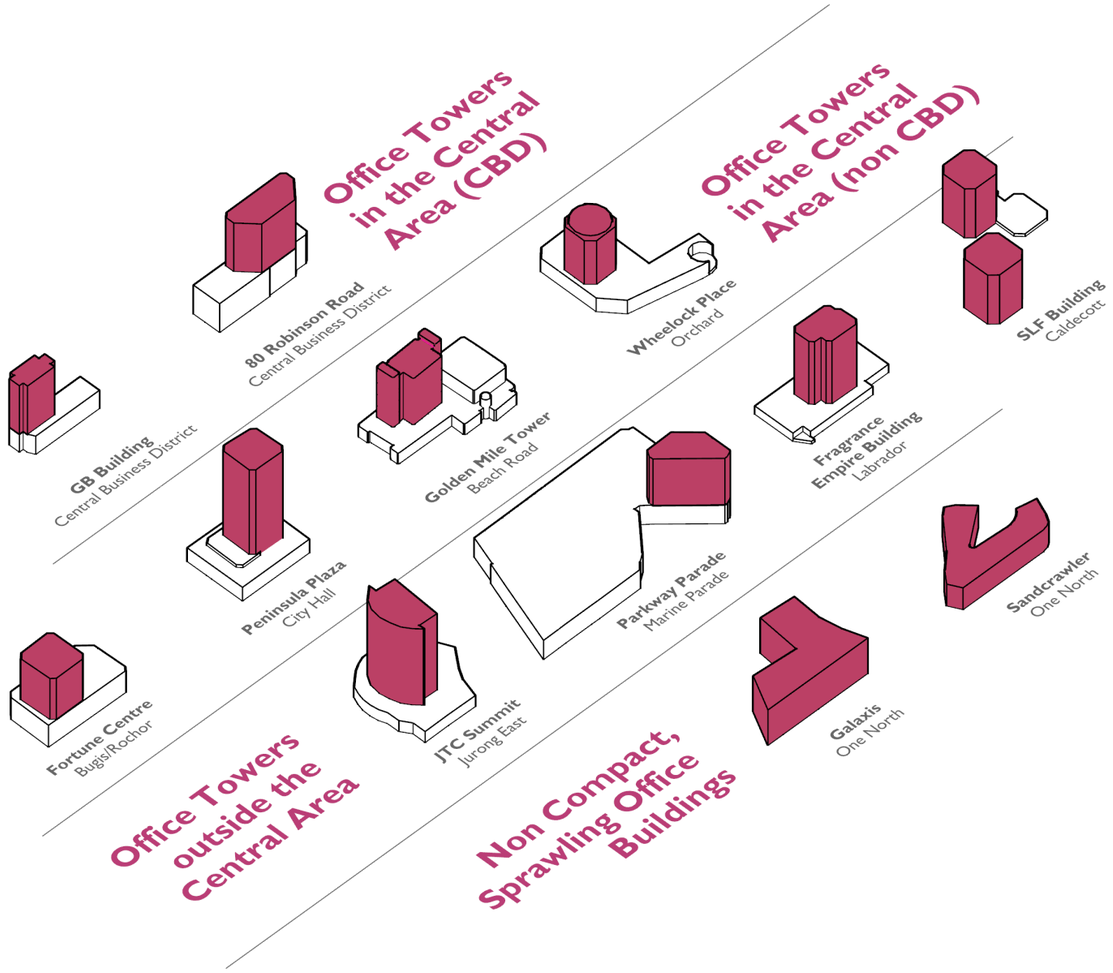
Stage 3

Full Feasibility Study

If the results of Stage 2 are positive, the developer may wish to engage a multidisciplinary team to conduct a full feasibility study of the proposed conversion. At this stage, the existing condition of the building will be ascertained through a comprehensive study of as-built information, building surveys and tests so that the full extent of the works can be derived. The feasibility study may be carried out in conjunction with the concept design stage to determine the specific interventions required for conversion.

Scope of Adaptive Reuse Potential Assessment Matrix

The Adaptive Reuse Potential Assessment Matrix focuses on compact office towers and their conversion to similarly compact residential and hotel towers. These types of office towers are commonly found in Singapore's Central Area, regional centres and business districts. The matrix may also be applied to non-compact, elongated office towers such as those in the one-north district.



CPG Design and Research Office

CPG's Design and Research Office (DRO) explores impactful design strategies and solutions for the built environment through practice-based research and built work. It works collaboratively with industry partners and tertiary institutions to drive design and research initiatives towards meaningful, actionable outcomes.

Research Team

Pauline Ang
Director (DRO)

Koh Xian Zhe
Senior Architectural Associate (DRO)

For more information, please contact:
DRO@cpgcorp.com.sg