

Chapter 43

Design Scenarios for a Circular Vision of Post-disaster Temporary Settlements



Maria Vittoria Arnetoli and Roberto Bologna

Abstract The construction sector has a considerable impact on the environment in terms of both exploited natural resources and greenhouse gas emissions. Therefore, converting the production process from linear to circular is essential. In increasingly vulnerable human settlements, post-emergency recovery can become an opportunity to develop innovative circular design strategies. The research focuses on how to strengthen the resilience of risk-prone territories through pre-disaster strategic planning based on a systemic approach. Post-emergency management of 2009 and 2016–2017 earthquakes in the inner areas of Central Italy is assumed as a case study. In particular, the tender specifications that guided the recovery revealed a deep lack of preventive programmes on the post-use phase of the settlements, which remain suspended between temporary and permanent. Starting from the analysis, the paper proposes a matrix of alternative scenarios for the end-of-life of temporary structures. The matrix allows connecting the recovery phase with the objectives of social cohesion and territorial regeneration policies, adapting the response to the needs of the specific context. Assuming that the artefact’s technological requirements depend on the different perspectives of their life cycle, the scenarios are oriented towards different degrees of reversibility, addressing the complete disassembly, with the reuse and recycling of components, up to the reconversion of temporary assets as local facilities and as resources for green and digital transition. Integrating post-disaster into ordinary tools would trigger virtuous synergies to optimise public funding use. In this framework, post-disaster temporary housing can become a field of experimentation for disaster-resilient communities and circular economy.

Keywords Emergency · Post-disaster · Temporary housing · Strategic planning and scenario · Circular design

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43.1 Introduction

Complex and interconnected emergency phenomena, derived from natural and anthropogenic origin, determine an increasingly widespread and articulated need for transitional living. Moreover, cities have a growing vulnerability and poor coping capacity. This requires a new approach to the issue of emergency management, addressing the overcoming of the distinction between the *ordinary* and *extra-ordinary time*.

To respond to this framework, the contamination between Urban Resilience and Disaster Risk Reduction is an innovative field to be explored (UN 2015). The challenge is to combine responses focused on restoring the built environment (*hard solutions*) with strategies aimed at strengthen the adaptive capacity of physical and social systems at risk and reduce the environmental impact of emergency solutions (*soft solutions*), turning emergency into a “window of opportunity” for increasing sustainability (Brundiens and Eakin 2018). Post-disasters should be addressed not to “bounce back” but to “bounce forward” towards a more resilient society able to face up future extreme events by an improved combination of resistance and adaptability (Alexander 2015).

Within the Italian context, the identified field of investigation is the post-earthquake temporary settlements, consisting of a structural component, the housing modules, and an infrastructural one, the set of services that connect the area to the technological and mobility existing networks.

The current process is strongly top-down and the institutional actors (NDCP—National Department of Civil Protection, SOR—Special Offices of Reconstruction, Regions, Municipalities) operate in a sectorial way.

The housing solutions, even if called temporary, have a strong environmental impact: at the product level, the components are not designed to be reintroduced into further cycles of use, this leads to an unacceptable waste of resources; while at the settlement level, the foundations and the infrastructures are not realised as reversible, consuming natural soil. From a socio-economic point of view, the significant public investments are subtracted from the reconstruction effort.

Therefore, the study aims to integrate Circular Design paradigms in pre-disaster planning (Fig. 43.1). Temporary Architecture reaffirms its role as a privileged field of experimentation for the development of production models and technical solutions based on circular economy and digitalisation processes (Antonini et al. 2020).

The study identifies the inner areas of Central Italy affected by the 2009 and 2016–17 seismic events as a priority case study due to the pre-existing overlapping of environmental vulnerability and socio-economic marginality, compounded by the current management of reconstruction and the future reconversion or dismantling of temporary settlements.

Starting from this framework a design tool focused on the entire life cycle of the temporary solutions is proposed.

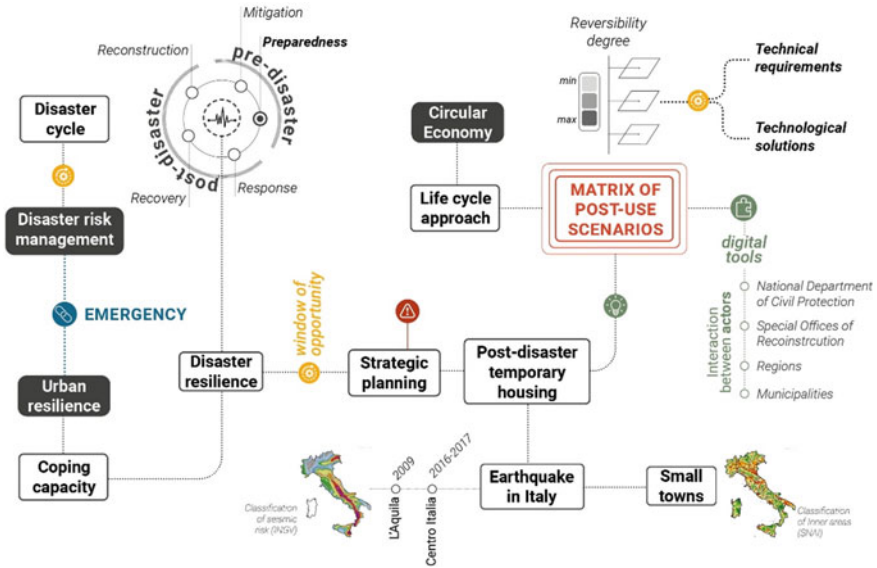


Fig. 43.1 Research map. Source Authors

43.2 From Temporary to Permanent: The Italian Context

In Italy, the need for post-disaster transitional housing derives mainly from the frequent earthquakes to which most of the territory is exposed, combined with other destructive events due to the high hydrogeological fragilities, such as floods and landslides.

The long reconstruction period, partly motivated by the pervasive presence of the historical heritage and the inefficiency and ineffectiveness of the public implementation processes, require housing solutions with adequate standards for a time of use of at least ten years.

Despite the numerous disasters faced in the recent past (Guidoboni and Valensise 2013), the response is still characterised by many issues, including poor humanisation of the spaces, lack of adaptability to the intervention context, and costs that are comparable or even higher than those of ordinary buildings.

A typical Italian problem, on which the research focuses, is the unresolved and contradictory relationship between the structures' temporary and permanent nature: solutions classified as temporary remain for decades. Striking examples are the "baracche" in Messina, built after the 1908 earthquake and still inhabited in seriously precarious conditions, or the *Bucaletto* district in Potenza, built in response to the 1980 earthquake, now hosting public facilities and under renovation. These are just two examples of the constellation of temporary settlements spread across Italy, which turn into areas of degradation exacerbating social inequalities and absorbing public investments (Fig. 43.2).

MAP OF THE MAIN EARTHQUAKES IN ITALY 1900-2017

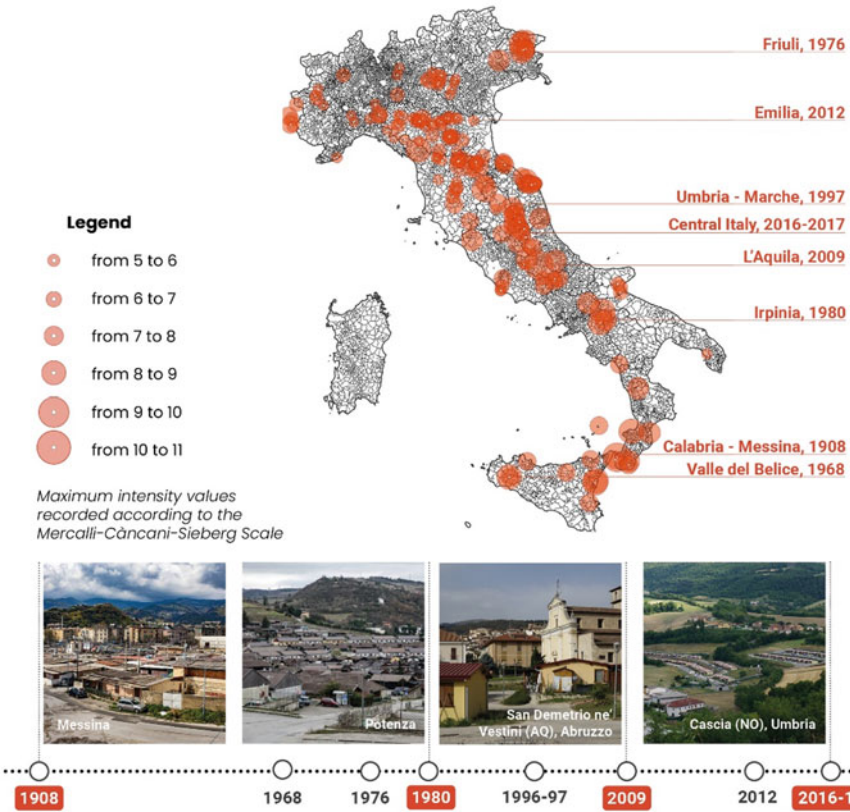


Fig. 43.2 Main earthquakes in Italy (1900–2017). *Source of data* National Institute of Geophysics and Volcanology; image elaborated by authors

At the root of this “permanent temporariness” phenomenon is a chronic lack of preventive and strategic planning. Concerning the disaster cycle, the weak role of the preparedness phase leads to responses designed to meet the immediate recovery needs, without a systemic vision that can orient the entire life cycle.

The procedural tools adopted by the NDCP for the provision and construction of temporary housing modules following the 2009 (*Capitolato Speciale 2008*) and 2016–17 (*Capitolato Tecnico 2014*) earthquakes were examined concerning their ability to guide the post-use phase (Bologna 2020). The two tender specifications define the product requirements without including them in the more complex and dynamic process of reconstruction and parallel socio-territorial regeneration of the affected areas. In both documents, the following are the reversibility requirements: disassembly of the system, recyclability of materials and reusability of elements and/or components.

However, these have not been sufficient to achieve the environmental sustainability of the interventions, remaining expressions of intent.

The current conception of the housing module frames temporary structures in a linear process that flows through the phases of pre-use (production, transport, construction) and use (management and maintenance), interrupting at the post-use, which remains suspended without a direction.

Post-emergency use should inform product design from the beginning (EEA 2017).

On the contrary, postponing the evaluation of end-of-life possibilities after a period of use of at least a decade brings to the less sustainable scenario: landfill disposal.

The broader question is «reorganise public action around the themes of multi-temporality and circularity of planning» (Balducci et al. 2021) and the production system.

To overcome this gap, it is necessary to be able to respond to the different needs of specific contexts by proposing different alternative scenarios.

43.3 Lessons Learnt from Central Italy Earthquakes

Thirteen years after the L'Aquila earthquake and five years after the one in Central Italy, the critical issues that emerge today regarding the future of temporary assets are outlined below. The relationship between module and area is fundamental in post-disaster planning, which has to deal with a changed territorial structure, disrupted firstly by the earthquake and then by temporary interventions, which in small towns often equal or even exceed the size of the original centre.

The aspects highlighted derives from the analysis of scientific literature, research experiences (NDCP-ReLUI 2019–2021) and direct talks with institutional stakeholders (NDCP, SOR); which were accompanied by field analyses that allowed defining a bottom-up view from local administrations, inhabitants and associations.

According to the investigations, the future destination of the temporary housing structures already installed on the territory is oriented according to two possible directions: dismantling or renovation. Regarding the infrastructural component, restoring the areas to their pre-event condition, mostly agricultural or natural, is economically unsustainable. While the degree of obsolescence reached by the structures is essential to evaluate whether or not reconversion actions can be undertaken.

Currently, the prevailing choice is to preserve settlements, except in the case of areas under landscape constraints or belonging to natural parks. The high cost of demolition and waste management and the fact that two different actors carry out the provision and management (NDCP and Municipalities) also suggests that settlements should be maintained.

In these evaluations, the municipalities are operating individually without a large-scale direction. The privileged functional destination of the reconversion seems to be tourism. However, this does not consider that the areas are oversized compared to the tourist flows involving these territories.

Moreover, the lack of public services is not considered, nor are the green and digital transitions goals, for which small towns could be a living laboratory. Sectoriality leads to a parallelism between public fundings that act on these areas, separately, as earthquake-affected territories and as inner areas. This strict division ignores that a large portion of the *crater* coincides with the 2014–2020 National Strategy for Inner Areas (Agency for Territorial Cohesion 2014) pilot project areas.

Moreover, as the reconstruction process is carried on, the modules are progressively inhabited not only by earthquake victims but also by other categories of users (elderly, young couples, immigrants). In this way, the most vulnerable population groups are concentrated in the temporary settlements, leading to greater marginalisation.

It is no longer acceptable that post-emergency interventions exacerbate pre-existing inequalities by failing to act as a driver for development, especially in the light of territorial cohesion purposes.

The lack of cross-cutting policies has led to the construction of structures with no end-of-life plan. The *MAP—Moduli Abitativi Provvisori* (Housing Provisional Modules) provided for the L'Aquila earthquake have already reached a high degree of obsolescence, while there are more significant margins for intervention on the *SAE—Soluzioni Abitative in Emergenze* (Emergency Housing Solutions) used in Central Italy.

Given the vast volume of modules spread across Abruzzo, Lazio, Marche and Umbria regions, it is urgent to consider alternatives to landfill or abandon.

In addition, once the modules are dismantled, the areas' infrastructures will remain without a functional destination.

These findings call for learning from past experience by promoting a radical change in post-disaster management: from linear to circular.

43.4 Matrix of Post-use Scenarios in a Circular Vision

For the criticalities highlighted, the approach to post-disaster temporary solutions must be rethought in the twin dimensions of process and product, according to the paradigms of circularity as a pathway to resilience.

This requires defining tools and methods for putting into practice the principles of *Design for Disassembly, Reuse and Recycle* (DfDRR), assuming that the technical requirements of the products defined in the design phase depend on their final destination.

Thus, a matrix of post-use scenarios is proposed as a preventive, strategic and inter-scalar tool that integrates the planning and the design level (Fig. 43.3). As part of the preparedness phase, the matrix allows to orient the response according to the needs of the specific contexts.

Moreover, the matrix is addressed to the multiple stakeholders involved in emergency management, primarily the NDCP and Municipalities, but also the private operators like manufacturers.

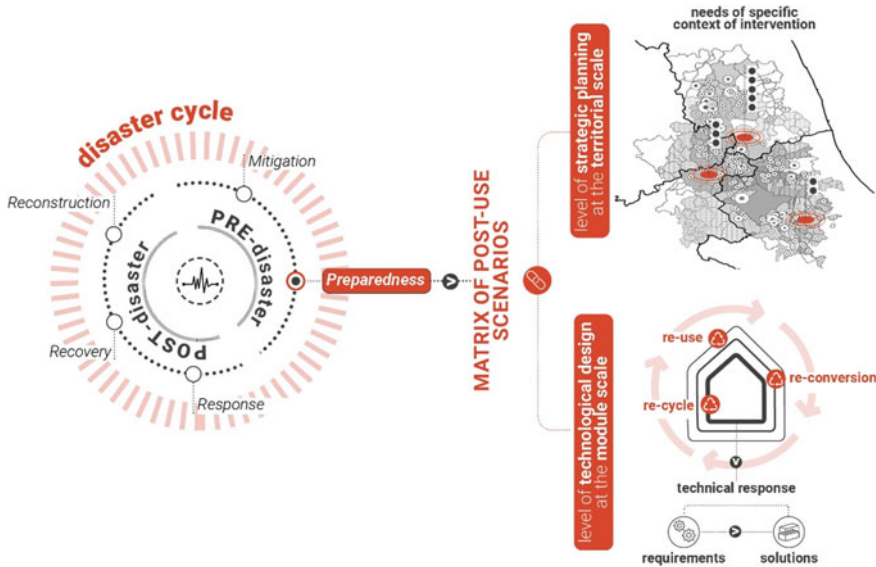


Fig. 43.3 Disaster cycle and inter-scalarly character of the matrix. Source Authors

The environmental issue changes the relationship between matter and time: the centre of the design activity becomes the product’s entire life cycle (Campioli et al. 2018).

The holistic approach moves toward an adaptive and evolutionary vision of the settlement’s life, reinforcing the integration between the phases of the disaster cycle.

Differently from the second life options explored by Johnson (2010), the matrix orients the end-of-life of the product from a technical perspective. The following four macro-scenarios (MS) move in a spectrum of design solutions from temporary to permanent (Fig. 43.4):

- *dismantle*: the structure is disassembled and its elements/components put into reuse and recycling processes, focusing on the features of the materials used;
- *disassembly*: the module is disassembled and reassembled elsewhere for further uses, with the same functional destination (residential) or others;
- *permanent core with temporary devices*: the device is composed of an infrastructural component designed as permanent, on which the temporary structures are integrated;
- *reuse*: the building is not designed as temporary but as an ordinary facility for the local community, designed to adapt in response to changing local needs.

To each MS corresponds different design parameters, which are translated into sets of technical requirements that correspond to different technical solutions. The main design features are flexibility and adaptability to allow subsequent transformations in the long-term period.

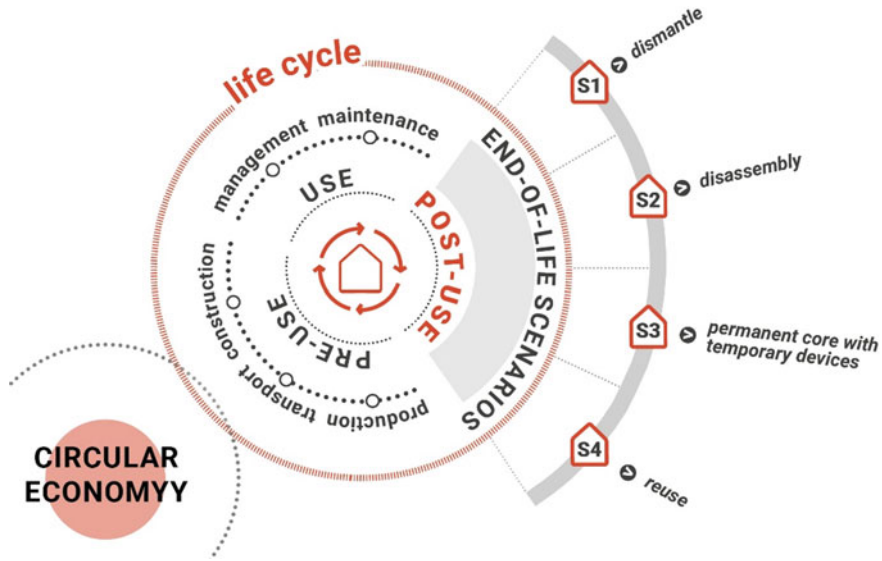


Fig. 43.4 Life cycle and post-use scenarios. *Source* Authors

The matrix embodies also the variety of solutions adopted in international contexts by analysing them with respect to the end-of-life trajectories of post-disaster temporary solutions (Arslan 2007; Askar et al. 2019; Johnson 2008; Seike et al. 2018), framing the Italian case in a wider horizon.

Emergency temporary housing needs to be rethought entirely at the different scales of the project, from settlement to single component.

For the vast scale, the challenge is to make the emergency response part of the policies operating in a specific territory. This can only be done during ordinary planning, as the emergency causes a time compression that does not allow the development of site-specific strategies.

The definition of the needs of territories at risk is the basis for planning emergency interventions combining national provisions and local realities.

The territorial planning dialogues directly with the technological system in the matrix (Fig. 43.5). The design approach is reshaped using time as an essential design resource.

The technical response is diversified in the four macro-scenarios, moving from temporariness to permanence.

For dismantle and disassembly scenarios, designing the supply chain and production process in a cradle-to-cradle logic, according to which the modules are derived from and destined for recycling circuits, would make it possible to test replicable solutions for other construction sectors.

While looking at the permanent core and the reuse, the requirements would be oriented towards standards closer to traditional constructions in terms of durability and adaptability of the structures.

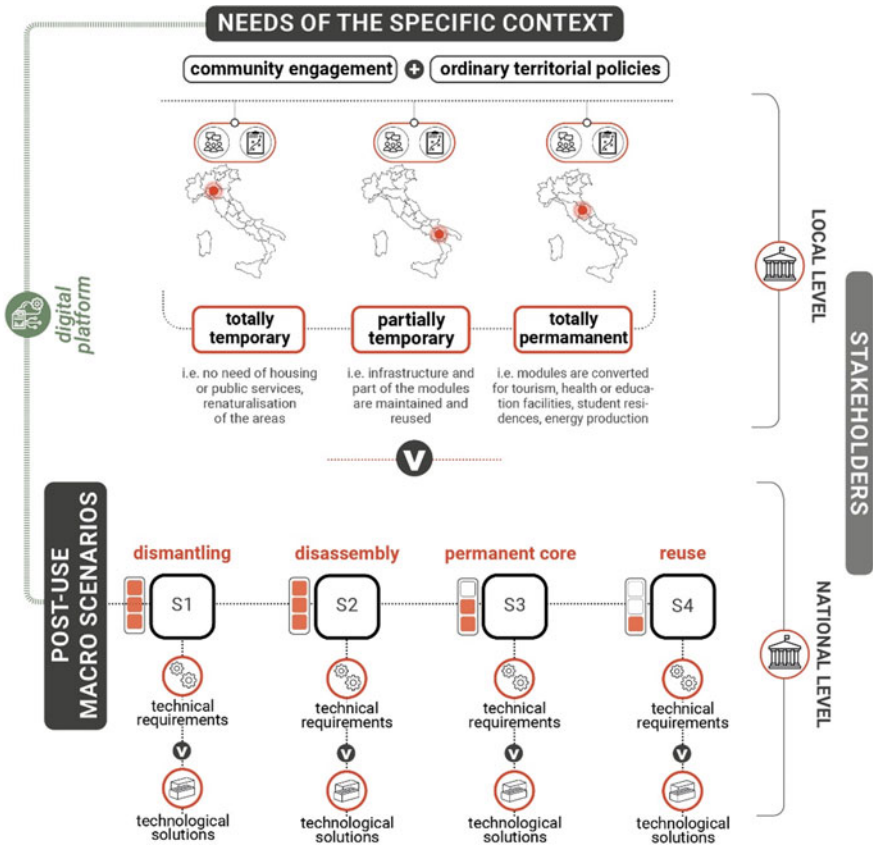


Fig. 43.5 Matrix of scenarios. Source Authors

In both directions, pre-disaster planning would make the emergency response a laboratory where different stakeholders such as universities, research centres, manufacturers, recycling sites could find common ground for collaboration and exchange.

A further dimension concerns the management of artefacts. This is closely linked to the logic with which the product is placed on the market, whether through traditional sale-purchase contracts, through which the public body takes possession of it or according to models that favour forms of sharing economy and product-service systems, acting on the concept of ownership.

In conclusion, the matrix is proposed as an open and dynamic tool, a link between the multiple actors, disciplines and sectors involved in the post-disaster temporary response, capable of operating directly on its multidimensional character.

The result achieved defines a methodological approach, the next step is to develop each scenario and implement the matrix as a digital open-source platform that can

be continuously updated and immediately integrated into the tools currently in use by the different stakeholders involved.

In the next phase of the research, pilot cases will be identified both in the Italian and international context to define the conditions of applicability and replicability of the matrix.

The application of the matrix with respect to different post-emergency management processes will allow to identify the potentialities and limits of the tool. At the same time, the selection parameters for each scenario will be defined using an inductive method, starting from local contexts with different socio-economic, environmental and regulatory profiles. This will lead to the definition of a set of basic and specific technical requirements.

43.5 Conclusions

The work presented is aligned with the evolution of emergency management towards environmental sustainability.

The purpose of the matrix is to determine the product's technical requirements according to the different scenarios chosen. Hence, the methodological framework leads to a practical result that directly affects the circular economy.

Therefore, due to their diffusion, the challenge is to transform temporary structures from a public asset difficult to manage from a legislative-administrative point of view and to reconvert from an urban-architectural one, into a resource for technological experimentation.

The process strategies and technical solutions developed are transferable to non-emergency construction, constituting potential good practices to be replicated.

The transformation most stressed in this paper is the green one. Again, digital tools also play a crucial role in the renovation of the current model. They can be used in the disaster cycle to strengthen the interaction between actors in the different phases and in the new-generation industrialisation of building production.

Transitional Living is investigated as a complex phenomenon interacting with the further challenges of Anthropocene societies, for which it is increasingly urgent and vital to define a new balance with nature by reducing their impact.

Looking at the design of the emergency management process, the ultimate goal is, then, to identify the preconditions for putting into practice a vision of circularity of resources.

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Account ig: @temp_researchnetwork

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