# Adria Wind Project – Possibility of development of offshore wind farm in the Northern Adriatic Sea

## Projekt Adria Wind – Mogućnost razvoja odobalnih vjetroelektrana na području sjevernog Jadrana

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**Ključne riječi:** odobalne vjetroelektrane, Jadransko more, LiDAR, mjerenje karakteristika vjetra

## Abstract

INA, d.d. is committed to transform our traditional fossil fuel-based operations into a low-carbon, sustainable business model. In order to achieve the set goals of the European Green Plan, the transformation of the industry is inevitable, and we consider it a great opportunity. The urgency of ensuring secure and affordable energy supplies while meeting climate targets has propelled wind power development into a new phase of even faster growth. In this context, INA d.d. is interested in exploring and evaluating the potential for construction of an offshore wind farm (OWF) in the Northern Adriatic Sea.

The first offshore wind measurement campaign in Croatia was conducted in North Adriatic by INA. The aim and scope of the wind campaign were to assess the wind potential at the designated area, to measure wind speed and direction, and then to interpret it in a wind study. The Wind Campaign started on 28 March 2022. LiDAR wind measurement devices have been installed on INA platforms Izabela North and Ivana A. The measurements of wind speeds and direction were monitored for 12 months to provide a better understanding of the wind regime on the site itself and a full bankable wind resource assessment considering the industry standards. To be able to better evaluate technical needs, a wider area in Adriatic, options for subsidies, permitting processes, and identify any additional risk or/and upside potentials pre-feasibility study is the natural next step.

Following the publication of the 2022 CEF (Connecting Europe Facility) Energy, INA applied for the Call for preparatory studies for cross-border renewable energy (CB RES) projects (CEF Energy 2022 – Call for Preparatory Studies for Cross-border Renewable Energy Projects | The European Maritime Spatial Planning Platform (europa.eu)) to implement exploratory tasks to identify and develop the main parameters of the planned CB RES project and to formalize the cross-border cooperation mechanism between Croatia and Italy in January 2023. INA's ADRIA Wind Project was selected for funding and the Grant Agreement was signed on 28 June 2023. CEF Energy will co-fund the preparatory studies that will help to assess the feasibility of a potential offshore wind farm in the Northern Adriatic coastal zone near Croatia and Italy. The preparatory study includes a technical, financial, and commercial assessment. The technical assessment, which will be the main objective of this paper, will include a preliminary technical study, elec-

trical and site resource assessments, an environmental and social impact screening, and will assess the potential implementation of interconnection between Croatia and Italy. If the studies' outcome is positive, and subject to the project final investment decision, the construction of the wind farm will significantly improve countries security of energy supply and increase renewable energy generation capacity while reducing $CO_2$ footprint.


## Sažetak

INA, d.d. predano transformira svoje tradicionalne operacije temeljene na fosilnim gorivima prema niskougljičnom i održivom poslovnom modelu. Za postizanje zadanih ciljeva Europskog zelenog plana, transformacija industrije je neizbježna i smatramo je velikom prilikom. Osiguravanje sigurne i pristupačne opskrbe energijom uz postizanje klimatskih ciljeva potaknula je sve brži razvoj tehnologije za iskorištavanje energije vjetra. U tom kontekstu INA, d.d. zainteresirana je za izgradnju odobalne vjetroelektrane u sjevernom Jadranu.

INA je provela prvu kampanju mjerenja vjetra na moru u Hrvatskoj, na sjevernom Jadranu. Cilj i opseg kampanje mjerenja vjetra bili su procijeniti potencijal vjetra na određenom području, izmjeriti brzinu i smjer vjetra, a zatim ga interpretirati u studiji vjetra. Kampanja mjerenja karakteristika vjetra započela je 28. ožujka 2022. LiDAR uređaji za mjerenje vjetra postavljeni su na Ininim platformama Izabela Sjever i Ivana A. Mjerenja brzine i smjera vjetra praćena su 12 mjeseci kako bi se dobio bolji uvid i pokušalo razumjeti karakteristike vjetra na samoj lokaciji te dati procjenu resursa vjetra koja može biti komercijalno isplativa, uzimajući u obzir industrijske standarde. Da bismo mogli bolje procijeniti tehničke potrebe, šire područje sjevernog Jadrana, opcije za subvencije, procese izdavanja dozvola i identificirati sve dodatne rizike i/ili potencijale izrada studije izvedivosti prirodni je sljedeći korak.

Nakon objave CEF (Connecting Europe Facility) Energy 2022, INA se prijavila na Poziv za izradu pripremnih studija za prekogranične projekte obnovljivih izvora energije (CB RES) (CEF Energy 2022 – Call for Preparatory Studies for Cross-border Renewable Energy Projects | The European Maritime Spatial Planning Platforma (europa.eu)) za provedbu istraživačkih zadataka za identifikaciju i razvoj glavnih parametara planiranog CB RES projekta i formaliziranje mehanizma prekogranične suradnje između Hrvatske i Italije u siječnju 2023. Inin ADRIA Wind Project odabran je za sufinanciranje i Ugovor o dodjeli bespovratnih sredstava potpisan je 28. lipnja 2023. CEF Energy će sufinancirati pripremne studije koje će pomoći u procjeni izvedivosti potencijalne odobalne vjetroelektrane u području sjevernog Jadrana u blizini Hrvatske i Italije.

Studija uključuje tehničku, financijsku i komercijalnu procjenu potencijala vjetra na području sjevernog Jadrana. Tehnička evaluacija, koja će biti u fokusu ovoga rada, uključit će preliminarnu tehničku studiju, procjenu električnih i resursa lokacije, procjenu utjecaja na okoliš i društvo te će procijeniti potencijalnu izgradnju interkonekcije između Hrvatske i Italije. Ako je ishod studija pozitivan i ovisno o konačnoj odluci o ulaganju u projekt, izgradnja vjetroelektrane značajno će poboljšati sigurnost opskrbe energijom u zemlji i povećati kapacitete za proizvodnju obnovljive energije uz smanjenje $CO_2$ otiska.


## 1. Introduction

The urgency of ensuring secure and affordable energy supplies while meeting climate targets has propelled wind power development into a new phase of even faster growth. In this context, there is an interest from INA side for the potential construction of an offshore wind farm (OWF) in the Northern Adriatic Sea.

The first offshore wind measurement campaign in Croatia was conducted in North Adriatic by INA. The aim and scope of the wind campaign were to assess the wind potential at the designated area, to measure wind speed and direction, and then to interpret it in a wind study.

LIDAR wind measurement devices have been installed on INA platforms Izabela North and Ivana A. The measurements of wind speeds and direction were monitored to provide a better understanding of the wind regime on the site itself and to get a full bankable wind resource assessment considering the industry standards. To be able to better evaluate technical needs, a wider area in Adriatic, options for subsidies, permitting processes, and identify any additional risk or/and upside potentials pre-feasibility study is the natural next step.

INA applied for the Call for preparatory studies for cross-border renewable energy (CB RES) projects (CEF Energy 2022 – Call for Preparatory Studies for Cross-border Renewable Energy Projects | The European Maritime Spatial Planning Platform (europa.eu)) to implement exploratory tasks to identify and develop

the main parameters of the planned CB RES project and to formalize the cross-border cooperation mechanism between Croatia and Italy in January 2023. INA's ADRIA Wind Project was selected for funding and the Grant Agreement was signed on 28 June 2023.

The Adria Wind Project consists of study preparation started on 1 September 2023 and the duration of twenty (20) months. Through using preparatory studies, INA aims to be on the CEF map to apply for future Calls for equipment & works co-financing.

The preparatory study is consisted of four different pillars:

- The technical assessment includes a preliminary technical study, electrical and site resource assessments, an environmental and social impact screening, and assess the potential implementation of interconnection between Croatia and Italy.
- The financial assessment covers the cost-benefit, risks, and opportunities analysis of the potential CB RES project.
- The commercial assessment run in parallel with the financial assessment. It analyses the market demand for electricity as well as the electricity price movements and monitor global energy trends on the market through a feed-in premium study and a Power Purchase Agreement assessment.
- Stakeholder engagement fosters communication and stakeholder involvement activities and cooperation activities between Croatia and Italy, including the assessment of cost-benefit sharing.

## 2. Offshore wind industry and site conditions

Offshore wind industry is expanding and developing every year. Average project size increases, with a lot of projects exceeding 1000 MW. Turbine size has increased from 2 MW to 12 MW in the last 20 years. For example Siemens Gamesa SG 14-222 DD with a capacity of up to 15 megawatts with power boost with rotor diameter of 222 m (https://www.siemensgamesa.com/global/en/home/products-and-services/offshore/wind-turbine-sg-14-222-dd.html) and Mingyang Smart Energy has announced that they are developing even larger wind turbine MySE with nominal capacity of 22 MW and 310+ meters rotor diameter which would reduce the number of turbines needed for a 1-GW offshore wind farm by 18 units, significantly reducing capital expenditure (https://windfarmmanagement.skf.com/the-worlds-most-powerful-wind-turbine/).

First step in assessing the possibility of constructing an offshore wind farm is taking a closer look into the site conditions and possible restrictions (Figure 1): wind speeds, seabed morphology and environment, geohazards (geology, seismic, geotechnics…), hydrodynamics and metocean conditions, coastal morpho dynamics, Natura 2000 and other protected areas, fishing areas and zones for mariculture, marine traffic and existing (in service and out-of-use) and planned infrastructure such as cables, pipelines, offshore substations and platforms, military areas, wrecks and archaeological areas, tourism and recreational activities.

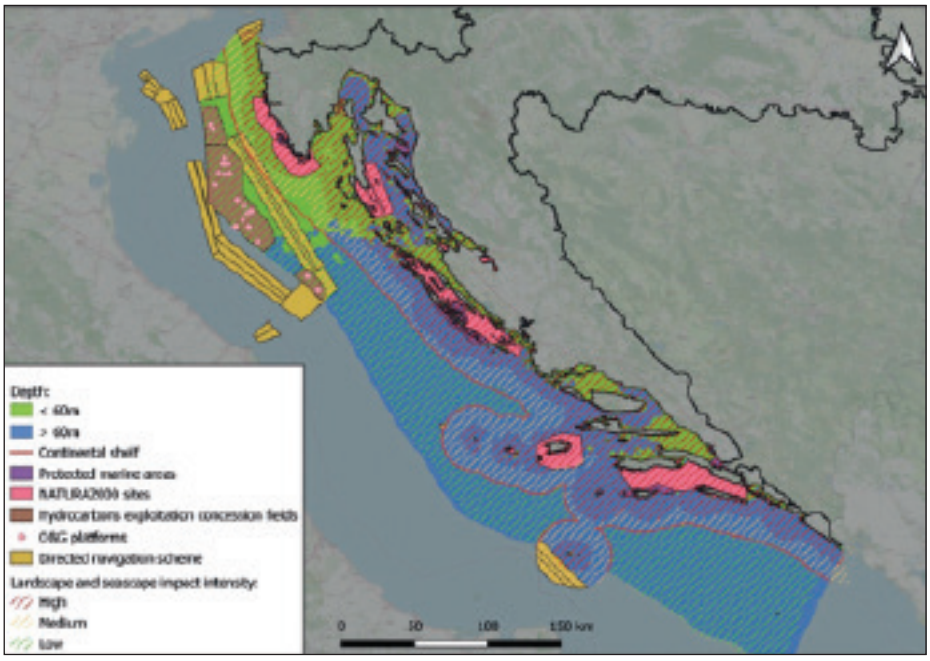


*Figure 1. Analysis of possible areas for the construction of bottom-fixed offshore wind farms (Action Plan for the uptake of Offshore Renewable Energy Sources in Croatia)*

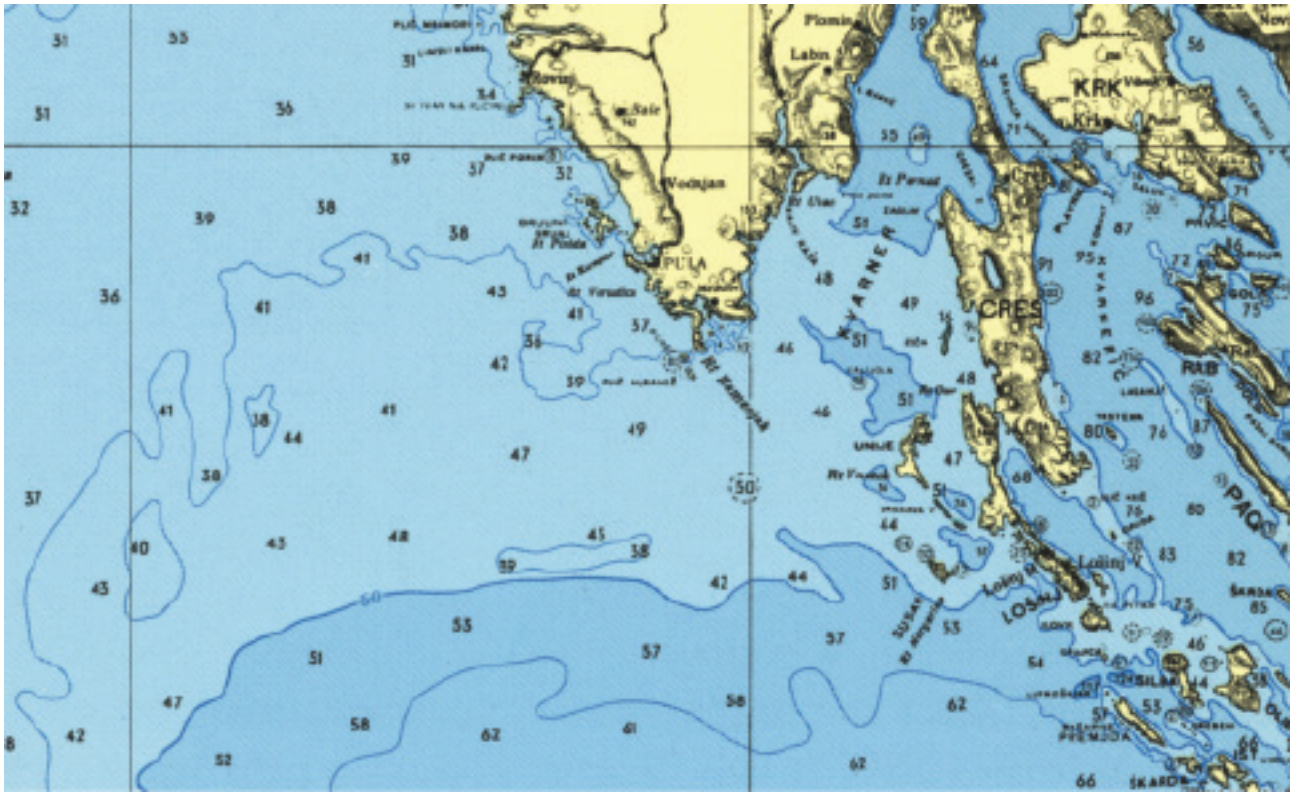


*Figure 2. Croatian Hydrographic Institute, Bathymetric map of the Adriatic Sea https://www.hhi.hr/proizvodi-i-usluge/pomorske-navigacijske-karte/detalj/pmid/2558*

Taking into consideration all of the nominated challenges together, OFW needs to be placed at least 12 nautical miles from the coastline, and that the maximum sea depth for construction of the bottom fixed wind farms is 60 m (Figure 2), this restriction delineates potential areas to a several location offshore Istrian peninsula.

If all the existing factors will be managed and overcome the most important parameter for OFW is wind speed and grid connection point. The first offshore wind measurement campaign in Croatia was conducted in North Adriatic by INA on INA's existing gas platforms Ivana A and Izabela N. This data is crucial for the development of offshore wind farms, as it is necessary to analyses wind characteristics and sea states for both wind energy assessment purposes and for the design of wind turbines.

Regarding the grid connection point there are several possibilities. Onshore 220 kV grid connection is currently available at Plomin (40 km to Pula) and will be available in Vodnjan (8 km to Pula) up to 300 MW by year 2032–2033 based on HOPS (The independent Transmission System Operator in Croatia) 10-year development plan. 400 kV grid is accessible at Rijeka with a theoretical capacity of 600 MW but due to the cross-border flows between Slovenia and Croatia free capacity is as well ~300 MW there. Since connection is limited in Istria there is a

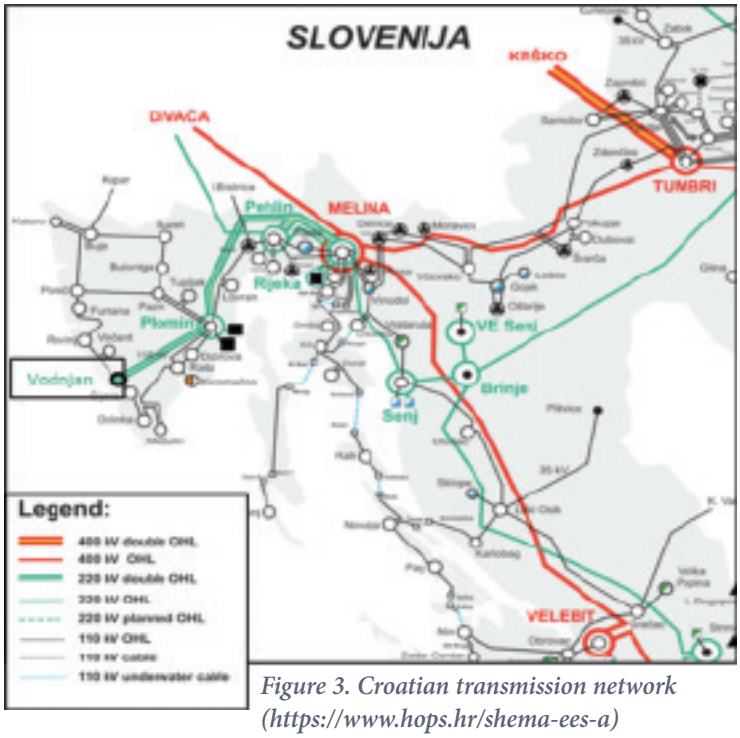


*Figure 3. Croatian transmission network (https://www.hops.hr/shema-ees-a)*

theoretical option to construct the Croatia-Italy interconnector with the possibility to sell electricity to the Italian grid as well, either by subsea high voltage HVAC or HVDC connection. Distance from Pula to Ravenna is about 120 km and it needs further analysis whether Italy is open for such an interconnector and which solution is more feasible.

## 3. Floating LiDAR Campaign

Light Detection and Ranging (LiDAR) is a remote wind sensing technology capable of measuring three-dimensional relative wind velocity at multiple fixed distances from the optical transceiver. The sensor transmits laser beams that interact with atmospheric constituents such as dust, aerosols, and pollen, along with other particulates as the laser pulses travel through the atmosphere towards the target plane. These atmospheric particles reflect the laser light back towards the receiver of the system along the beam path, known as backscatter. In doing so, the velocity of the backscatter (which represents the speed and direction of the air mass) is imprinted onto the reflected laser signal in the form of a Doppler frequency shift. Using the concept of time-of-flight, the reflect laser signal is gated in time so that the data represents a measurement at a particular range from the optical transceiver. The accuracy of LiDAR systems has been tested against meteorological masts with wind sensors in both onshore and offshore settings. (Chung-Yao Hsuan et al. / Energy Procedia 61 (2014) 1699 – 1702).

First offshore wind measurement campaign in Croatia was carried out by INA. LiDAR are currently installed and operational on INA's existing gas platforms Ivana A and Izabela N (Figure 4) and the data interpretation in ongoing. INA is planning to execute another wind measurement campaign, but now on the open sea, for which a floating LiDAR bouy is needed. The purpose of the additional wind campaign is to obtain precise wind data in the different area in North Adriatic Sea and to determine the most suitable area for offshore wind farm construction regarding both the wind characteristics and environmental impact. Based on the market research conducted by INA, there are several eminent companies in this field that provide turn-key floating LiDAR wind measurement services. It is important to have in mind that gathering at least a full year wind measurements data will be needed to be able to properly design OFW. Also, the lead time for this kind of device is between

*Figure 4. LiDAR device installed on INA's gas platform in the Adriatic Sea*

6 and 9 months and cost exceeds one million euros for one LiDAR buoy. Which means almost 2 years until the necessary data will be gotten. LiDAR buoy is equipped with redundant satellite, WiFi and 4G communication devices. Averaged wind data is transmitted near real-time and raw data is transmitted daily. The buoy uses solar panels or micro-turbines to harness renewable energy to recharge internal batteries. For redundancy, the buoy has independent power systems and can run off either or both power sources and can run for several days without any charging from the sun or wind, depending on the service provider. There is an option to install additional sensors for gathering meteorological and environmental data, for example, current profilers, water temperature, salinity, and water level sensors.

*Figure 5. Floating LiDAR EOLOS solution https://eolossolutions.com/*

## 4. Preparatory Study for Establishing an Offshore Wind Farm in the Northern Adriatic Sea

INA applied for the Call for preparatory studies for cross-border renewable energy (CB RES) projects (CEF Energy 2022 – Call for Preparatory Studies for Cross-border Renewable Energy Projects | The European Maritime Spatial Planning Platform (europa.eu)) to implement exploratory tasks to identify and develop the main parameters of the planned CB RES project and to formalize the cross-border cooperation mechanism between Croatia and Italy in January 2023. INA's ADRIA Wind Project was selected for funding and the Grant Agreement was signed on 28 June 2023. The preparatory study is consisted of four different pillars: (I) technical assessment, (II) financial assessment, (III) commercial assessment and (IV) stakeholder engagement. The technical assessment will include a preliminary technical study, electrical and site resource assessments, an environmental and social impact screening, and will assess the potential implementation of an interconnection between Croatia and Italy. Further to the technical assessment, the financial assessment will cover the cost-benefit, risks, and opportunities analysis of the potential CB RES project. The commercial assessment is running in parallel with the financial assessment and would analyse the market demand for electricity as well as the electricity price movements and monitor global energy trends on the market through a feed-in premium study and a Power Purchase Agreement assessment. Lastly, the stakeholder engagement fosters communication and stakeholder involvement activities and cooperation activities between Member States, including the assessment of cost-benefit sharing.

The technical assessment will start with reviewing all existing studies and relevant data that could be gather from an open source. Regarding the geology and seabed morphology INA holds knowledge and necessary data that was gathered during the exploration and production of the hydrocarbons in the North Adriatic. INA comparative advantage in this project is its technical archive. Extensive geotechnical studies were made as well as soil analysis which were carried out for the construction of the platforms itself. Based on the available information and considering best practices both in the regional as the global offshore wind market, a selection of the following will be made to develop a basis for conceptual design solutions. Selection of wind turbine type, depending on wind climate, overall market trends, infield cabling type and voltage. Also, a study will be performed to investigate suitable foundation options based on turbine types, water depth, bathymetry, and soil conditions.

Financial assessment will provide detail CAPEX and OPEX breakdown of technical costs:

- Wind turbine generators (WTG)
- Foundations
- Infield and Export Cables
- Offshore substation
- Transport and installation
- Onshore grid connection
- Insurances
- Others
- O&M contract costs for WTG and Foundation, Cables, Substations
- Employees
- Logistics

Commercial assessment focuses on high-level commercial market assessment with an overview of the potential market, market conditions, potential buyers, and potential feed-in premiums as well as an overview of the key power purchase agreement PPA aspects. Also, it will cover the overview of the market demand for electricity in the Adriatic Sea region focused on the most likely connection points (Croatia and Italy to be) and key potential buyer profiles (physical and corporate PPAs) will be identified.

## 5. Conclusion

Offshore wind industry is fast developing every year, raising an opportunity for Croatia to utilize the potential of the Adriatic Sea. In the coming years, it will be important to advocate for development of a comprehensive legal framework to support offshore wind projects. In Croatia, the regulatory framework is currently being developed. However, there is need for further clarification regarding the tendering rules and incentive schemes. Financially, offshore wind energy is considered less viable compared to onshore wind and solar energy. Consequently, this matter is not a primary focus for the legislator at this. Is important to note that, based on experience in Germany and Denmark, the creation of an offshore wind legislation framework could take up to five years.

Wind measurement campaign is essential for the development of an offshore wind farm. It will determine the proper wind turbine type, enable energy

yield, and wind resource assessments which are crucial for project evaluation. It is important for all interested parties that this campaign starts as soon as possible due to long lead and measurement time (practically 2 years).

Offshore wind farm project in the Adriatic Sea is only viable with the proper wind speed for which the floating LiDAR measurement campaign is needed. Additionally, due to the specific conditions of the micro-location for the construction of the OWF, co-financing is essential and necessary for the implementation of such projects.

Implementation of an offshore wind project will bring many benefits to the local communities and will enable a fulfilment of renewable energy sources obligations in Croatia.

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