Swiss Fire Protection
Research & Development AG

Comparison of techniques

for extinguishing storage-tank fires

from a financial point of view

While safety can never be a question of money, any economically responsible organization must keep financial considerations in mind. Imagine, then, the advantages of a revolutionary firefighting technology that has an extinguishment capacity unlike any other – a system that not only saves lives and property, but is also budget-friendly for companies.

This document compares the **costs of installing and maintaining** the various fire-safety systems that protect industrial sites. Our goal is to offer a factual, thorough and scientifically based analysis of the financial advantages and drawbacks of each system, in hopes that this data might be of use to managers of storage-tank farms, chemical plants and other facilities.

Comparing Technologies

Our study considers only those technologies that are capable (at least in theory) of extinguishing a full-surface fire on a storage tank containing combustible liquid. We have divided the traditional technologies into three categories that cover the bulk of extinguishment systems currently on the market: **mobile**, **semi-stable**, and **fixed**.

We calculated the systems' installation and operational expenses according to the prevailing standards published by the National Fire Protection Association (**NFPA**) and European Standards (**EN**).

At the end of this document, we append a short table that compares the various aspects of these firefighting technologies above and beyond financial considerations.

Since these systems are usually built for more than one storage tank, we calculated costs for installation (CAPEX) and maintenance (OPEX) at a **theoretical, medium-sized tank park** comprising 20 crude-oil tanks, each with a diameter of 50 meters.

In order to ensure accurate comparisons, we had to consider each technology's functionality under identical circumstances. It was therefore necessary for us to narrow our scope and avoid delving too deeply into details. Under no circumstances does this impinge upon our professional standards; when we simplify things, we always elucidate our reasons. One important simplification is that our analysis **does not calculate** costs for extinguishing **simultaneous fires** on multiple tanks, but rather for putting out a blaze on a single tank. We limit our discussion to storage-tank fires, whereas in reality, storage tanks are usually part of a much larger facility with technological installations that cost many times more than the tanks themselves. Likewise, this survey does not consider the fact that mobile and semi-stable systems have a significantly higher response time than fixed systems, which means a fire can inflict much greater damage on the facilities when such systems are employed. We also do not discuss the extinguishment of fires in the **dike** and **other technological areas**.

The **Pi Foam System is perfectly capable of protecting these areas as well**, but we have decided to omit them for the purposes of this study.

For the sake of simplicity, our calculations start at the very beginning of each investment. We assume that each fire-protection system is a **greenfield project**.

Financial projections

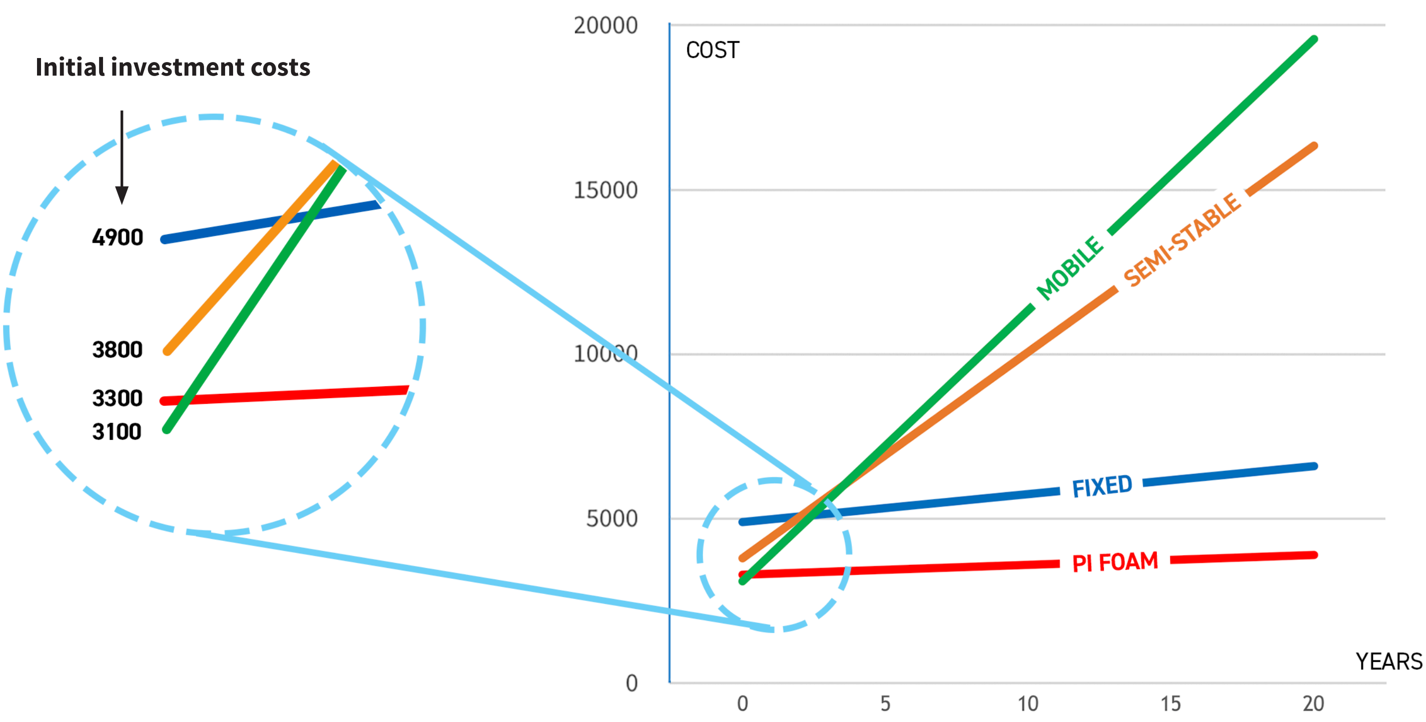
From a purely financial point of view, it may seem that the cheapest option would be not to construct any fire-protection system at all. This is quite true – so long as no accidents occur. But this cannot be a realistic option. Responsible companies cannot trust in blind faith. Failure to take any fire-protection measures drives up the cost of risk in a company's financial projections, since an **out-of-control blaze could destroy the entire premises**.

Luckily, the odds of a combustible-liquid storage tank catching fire are fairly small, but a rim-seal fire statistically occurs every day in some part of the world. Moreover, every year we hear about several full-surface fires that sometimes spread to other tanks and may consume an entire facility (e.g. the Jaipur or Buncefield incidents.)

We evaluated the financials for each of the four systems from two standpoints: First, the **number of years** it would take for an investor **to break even** on his initial investment (compared to the cost of a theoretical alternative); and second, the **total expenditures** that each system would require over a 20-year period.

At first glance, a fire-extinguishment system does not generate profit, so it may be difficult to understand the concept of "breaking even." However, we can calculate a "break-even" cost by calculating the **dollar amount of the damage** that a full-surface fire would inflict on a single storage container at our theoretical tank farm. We then **multiply** this by the **annual statistical probability** of such a fire breaking out. This becomes our **"alternative cost" – that is, the cost of "risking it" by failing to install a fire-extinguishment system.** Once we determined this alternative cost, we compared it to the annual OPEX for a single tank equipped with one of the fire-extinguishment systems in our survey. If annual OPEX is greater than the alternative cost of risk, then the system will never break even.

Cummulative costs in 20 years (in thousand USDs)

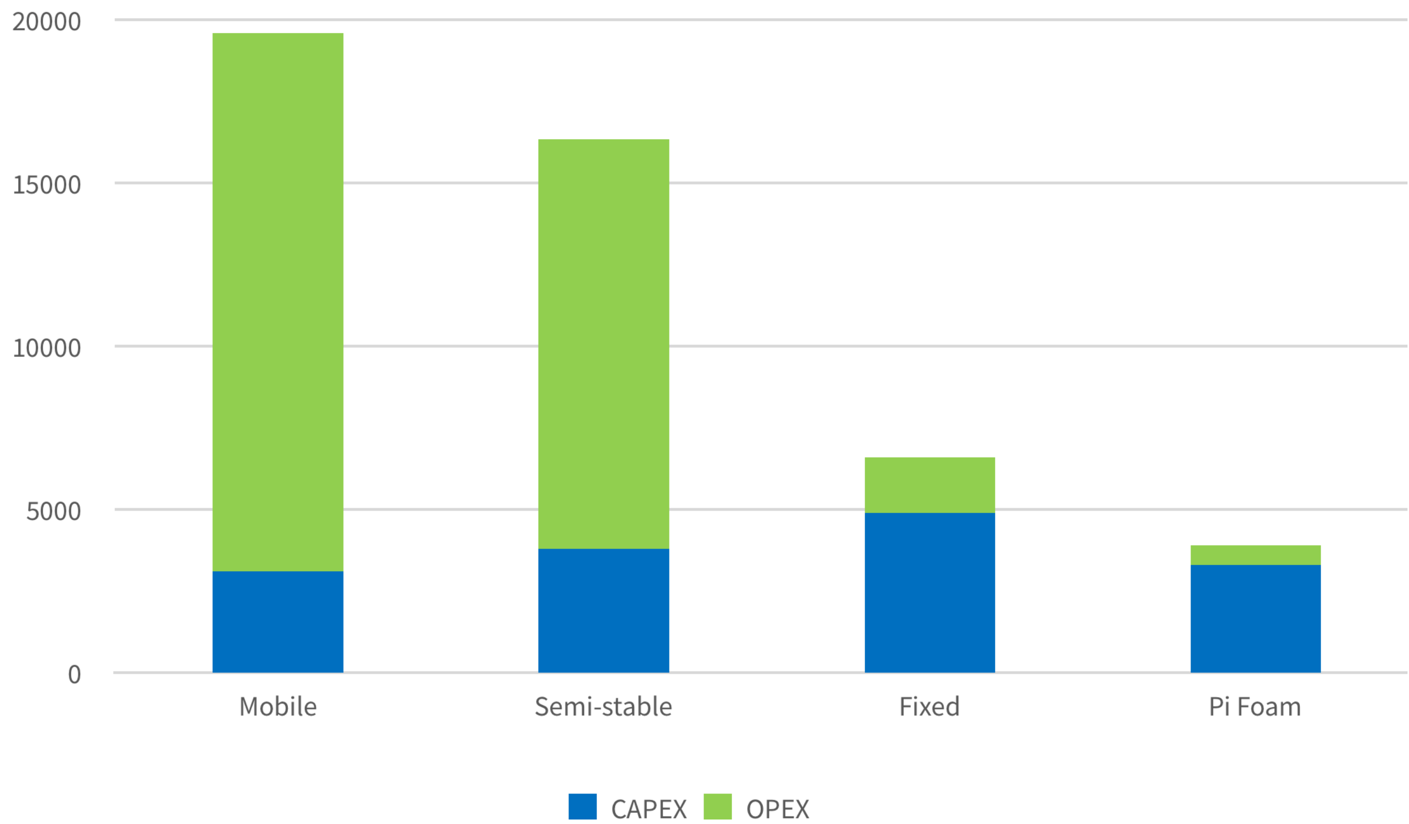


However, if there is a "profit" – that is, if the system's annual OPEX is less than the cost of "risking it" – we calculated how many years it would take for the investor to break even on his CAPEX for installing the system at the tank.

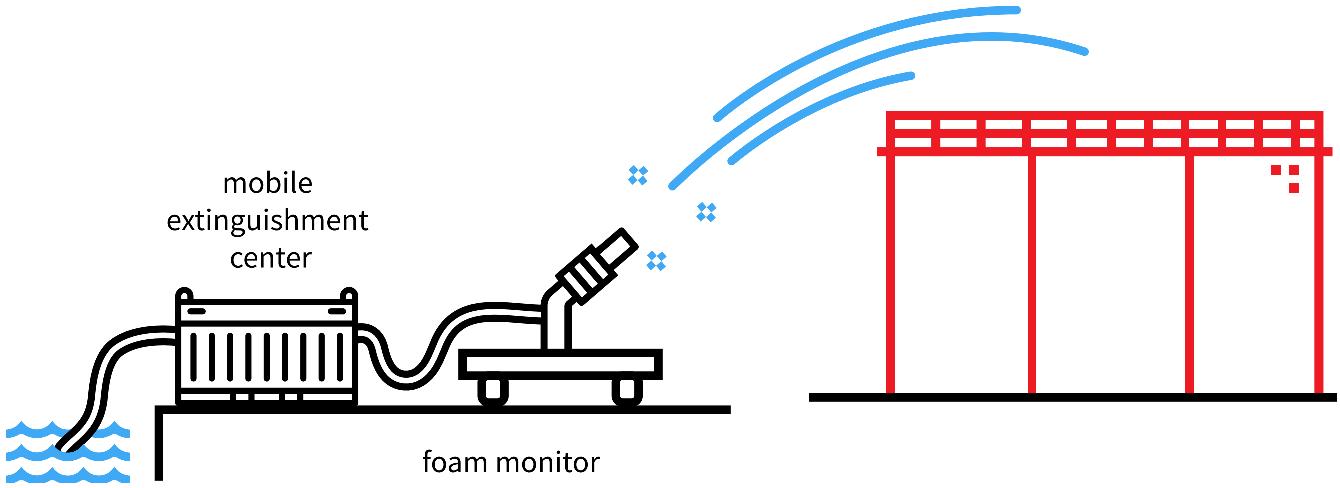
This is just one side of the coin. In order to get a clear picture of a firefighting system's financial implications, we also need to examine **total projected expenditures over a 20-year period**. This is because a given technology may have relatively low upfront investment costs, but will incur high operating costs later on. If an investor picks such a system to protect his tank park, he might break even on his installation costs fairly quickly. However, as operating costs pile up over two decades, the investor ultimately spends twice as much as he would have had he selected an alternative technology. For this reason, our survey considers both the number of years required to break even and projected expenditures over 20 years. We always present these two numbers together.

When evaluating our competitors' systems, we tried to select the **most efficient** options from a **price-to-value standpoint** so as not to make errors in overpricing. For instance, when examining fixed systems, we calculated the cost of a pipe network using Chinese-made steel products; we also used prices for Chinese-manufactured pumps, so long as they meet NFPA standards. We used developing-nation rates when calculating the cost of labor and the price of maintaining a firefighting force, even though these may be many times less than the same costs in a developed country. For example, we estimated total monthly expenses for a single firefighter, including equipment, at USD 1,200; this would be roughly USD 700-800 in India and might be USD 4,000-4,500 in the USA.

Total costs over 20 years (in thousand USDs)



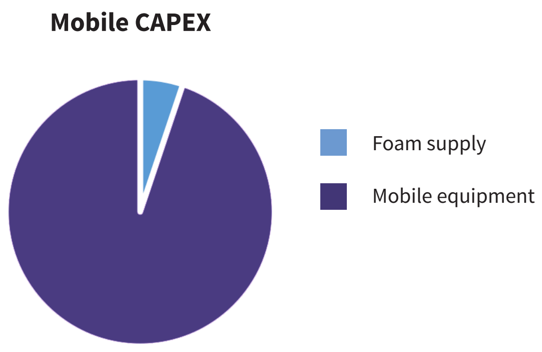
Mobile extinguishment

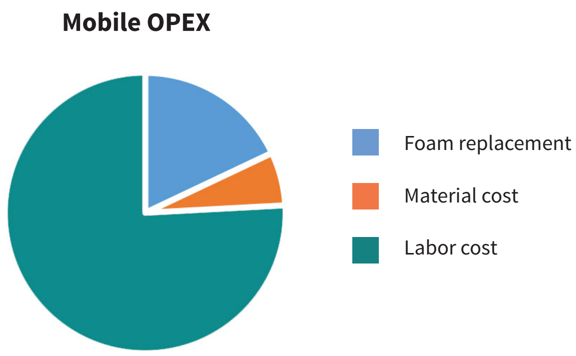


For mobile systems, we tried to concentrate solely on the mobile aspects of the technology. In other words, we did not include the cost of constructing a water network in our CAPEX calculations, but rather focused on the cost of procuring **high-capacity foam monitors** and **mobile pumps** (setting aside from the cost of smaller supplementary items and firefighting equipment.) Our calculations presume a nearby, inexhaustible supply of water for operating the offtake pumps. On the OPEX side, we considered the costs of maintaining the components, of procuring expendable items (foam, fuel), and of funding and equipping an in-house firefighting team whose members will operate the system.

A mobile-extinguishment system may appear cheaper than other options on paper, but one must always remember the need to pay these firefighters' salaries and furnish their equipment. Our calculations therefore include the cost of **keeping a specialized firefighting team on the premises 24 hours a day**. This is obligatory, because "normal" firefighters have neither the training nor the equipment to put out a full-surface fire of this magnitude.

While mobile systems may be considered "cheap," the reality is that **even the initial investment costs are significant**. There is no need to purchase heavy-duty machinery, but mobile pumps and high-performance foam monitors cost just about as much. In our model, a mobile system would require three rapid-reaction vehicles, a separately deployable pump station, two mobile-extinguishment units, two deployable monitors, and of course the auxiliary equipment and foam concentration necessary to operate these items. The total upfront investment (CAPEX-mobile) comes to approximately USD 3.1 million, or USD 155,000 per storage tank.





When calculating operating expenses, we naturally included maintenance costs. But the truly cumbersome component of OPEX is **paying for firefighting personnel**. If we assume three shifts of 12 firefighters plus a few additional workers, the cost comes to USD 41,200 per storage tank, which grows to USD 824,000 over a 20-year period.

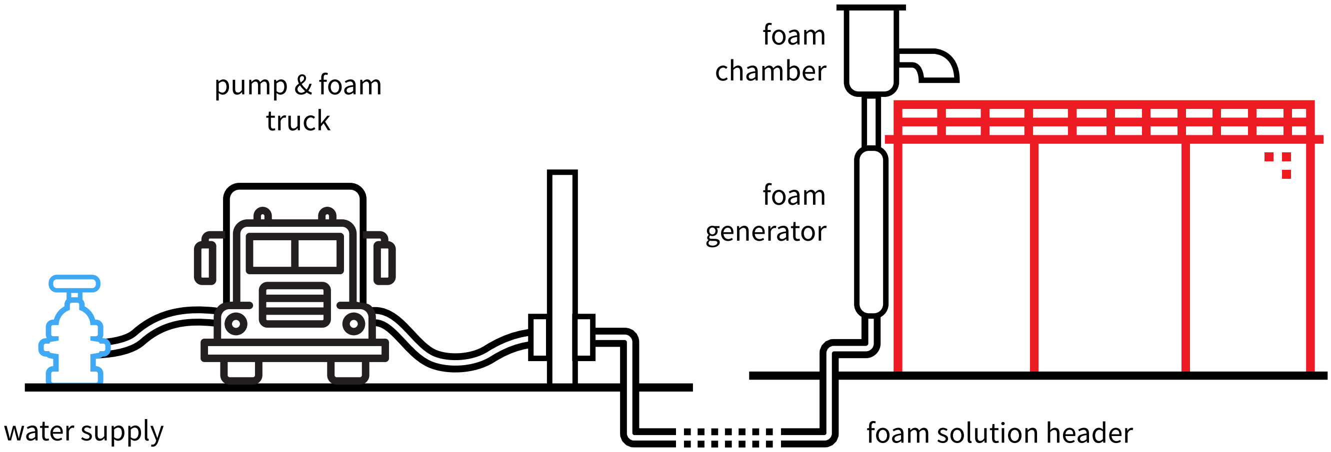
Thus the total budget for a mobile-extinguishment system for 20 years comes to USD 979,000 per storage tank or **USD 19.58 million for the entire tank park**. While the upfront installation cost is among the least expensive, this type of technology proves to be the most expensive in the long term. Moreover, a mobile system's unit costs can easily become buried in other budget items and therefore may be difficult to discern.

USD 19.58 million
over 20 years

Break even
not possible

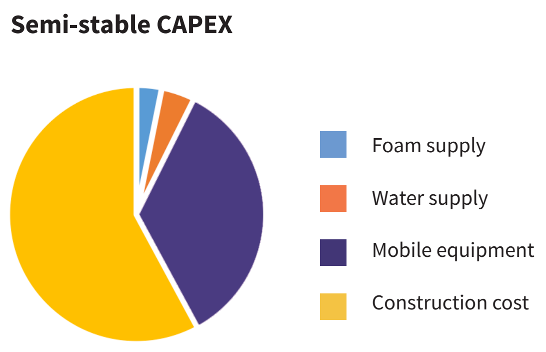
Since the annual operation costs are significantly higher than the alternative cost of risking a fire event, the **break-even point for mobile-extinguishment systems is indefinable**. It is not that there is no return on the upfront investment; rather, the high year-to-year expenses mean that the investor will never break even.

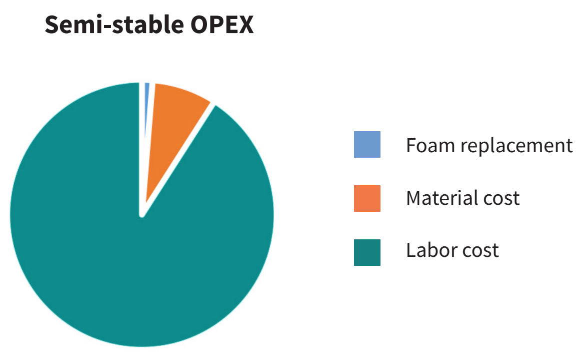
Semi-stable systems



For semi-stable systems, we included all of the items that appeared in our mobile calculations, except the foam monitors and the mobile submersible pumps. We also counted the cost of building **water works**, procuring water pumps (also with access to an inexhaustible water supply), a **firewater system** with fire hydrants, a **fixed-pipe network from the protective wall**, **foam generators**, a foam chamber and foam pourers. Naturally, we included the expense of maintaining the system and financing an on-site firefighting team.

These systems resemble mobile-extinguishment technologies in many respects. The main difference is that the upfront investment is slightly higher. It remains necessary to maintain a permanent team of firefighters; however, a semi-stable system does not employ foam monitors, so investors can theoretically save on these expenses. In reality, it is ineffectual to build a semi-stable system, because when a tank fire breaks out, it is usually necessary to call in mobile capacity as well. Our analysis disregards this fact and focuses exclusively on the costs of operating the semi-stable system itself.





Investors like semi-stable systems because of their relatively low installation costs. But if we take into account the cost of constructing an entire fire-water system (excluding the reservoir), plus the cost of mobile pumps and the related equipment, the startup costs become quite ponderous indeed. According to our calculations, installation costs (CAPEX-semi-stable) are approximately USD 3.80 million, or USD 190,000 per storage tank.

Operating costs rise significantly due to the necessity of **keeping a firefighting staff in three daily shifts**, which dwarfs the (not insignificant) cost of maintaining the system. All told, an investor can expect to spend USD 627,000 per tank over a 20-year period.

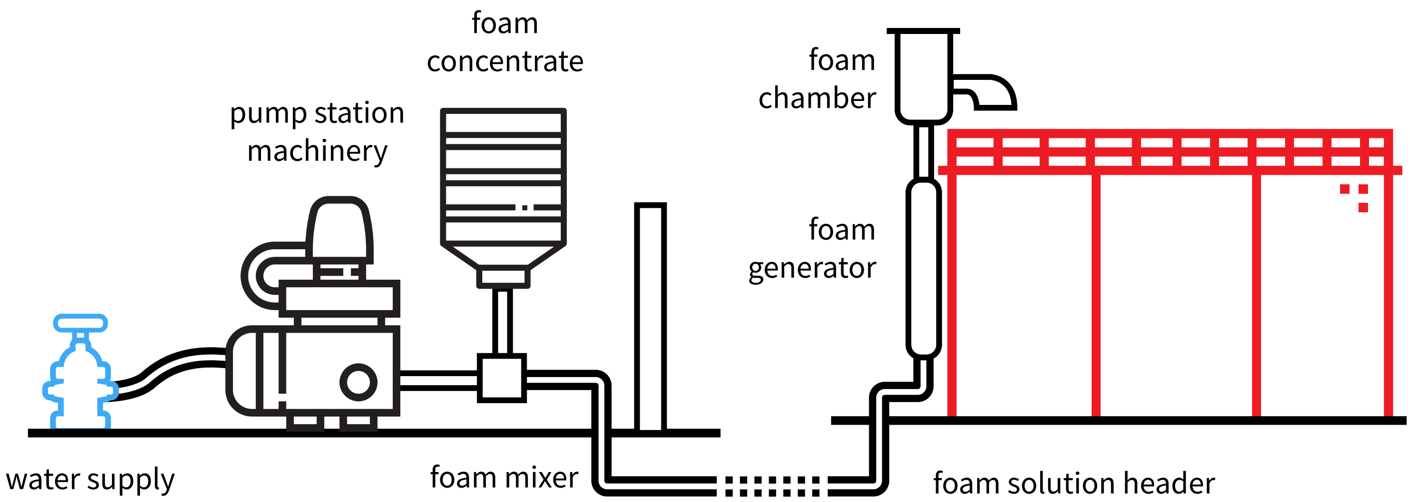
USD 16.34 million
over 20 years

Break even
not possible

Thus the cost of installing and operating a **full semi-stable extinguishment system over 20 years** is in the neighborhood of **USD 16.34 million**.

Since annual operating costs are also higher than the alternative cost of risk, there can be **no break-even point** for the investor.

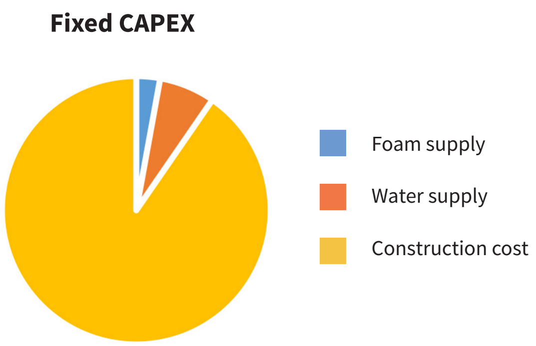
Fixed-extinguishment systems

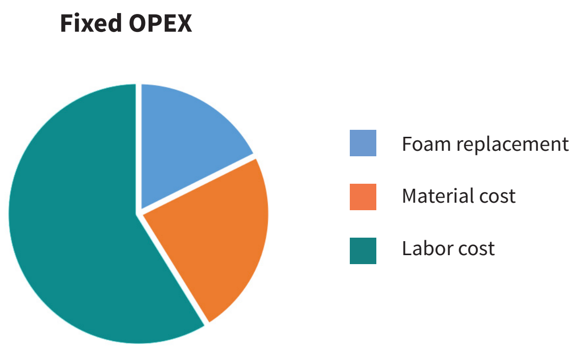


For traditional fixed systems, the CAPEX for construction includes the cost of **pumps, foam mixers, foam vessels, a water network,** and a volumetric **water reservoir** as specified in industry standards. On the OPEX side, labor costs are much lower than they are for mobile or semi-stable systems. However, the cost of maintaining the machinery of a fixed system is extraordinarily high because such **sophisticated technology requires regular testing and continuous maintenance.**

The two standard writers in this study, NFPA and EN, offer similar prescriptions for constructing fixed systems, but they differ slightly in their determinations of target values. These differences do not oblige us to postulate two different budgets. When cost differences arose due to a disparity between standards, we used the average of the two amounts in our calculations.

As might be expected, the **upfront investment is significant**. However, this expense gets shared out among the tanks quite evenly at a park of this size. With fixed technology, the cost of machinery is essentially the same whether the system protects a single tank or an entire tank park. The principal difference is the length of the pipe network, which is a relatively minor expense.





We assumed two pumps whose capacity was determined by the standards. (Here, we did not consider the fact that certain people say the NFPA-prescribed capacity of 4.2 l/min/m2 is hardly sufficient to put out a fire on a tank of this size, and would certainly be inadequate for extinguishing a blaze on a larger tank. Our calculations use the capacities prescribed in the standards.) We also included the cost of a pipe system and a simple detector system for the pumps.

The installation cost (CAPEX-fixed) for a single tank comes to USD 245,000, or a total of USD 4.9 million for the entire tank park.

The bulk of the **operational expenses** stem from the **cost of maintenance** and the need to conduct **regular tests** on the diesel pumps and the pump network. Our calculations are based on the stipulations set forth in the NFPA 25 standard. We attempted to use the lowest equipment prices to ensure that any error would favor our competitors. We arrived at annual operating costs of USD 85,000 for the entire fixed fire-extinguishment system, or USD 1.7 million over 20 years. In a developed country, these costs would be significantly higher.

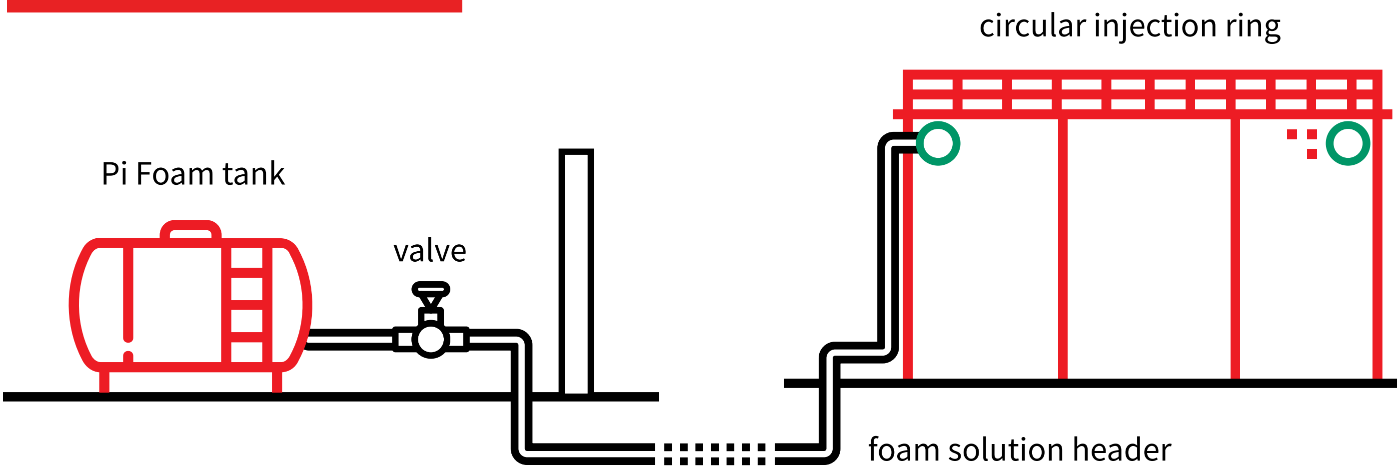
USD 6.6 million
over 20 years

Break even
in 15 years

Under NFPA and EN standards, a complete fixed system at our theoretical tank park would incur expenses of **USD 6.6 million over a 20-year period**.

Here, we can finally discuss a return on investment, because the OPEX is lower than the alternative cost of risk. An investor who chooses a fixed system would **break even in approximately 15 years.**

The Pi Foam System



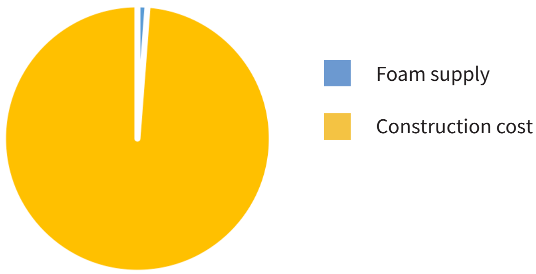
For the Pi Foam System, we calculated the cost of construction and maintenance. The latter **is a fraction of the corresponding costs for any of the above systems** because it is not necessary to support a standby firefighting team or pay their (not insignificant) salaries. Moreover, there is no need to conduct continuous tests or pay for maintenance on the sophisticated machinery.

Our system qualifies as a **fixed-automatic system, without the complicated machinery** of a traditional fixed system. This allows for savings on operations costs as well as significantly **greater operational reliability.**

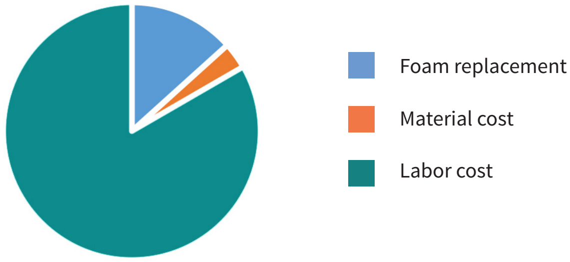
For our theoretical tank farm, we would construct a centralized foam system. In other words, we would not install a pressurized-foam vessel at each individual tank, but rather all tanks would be protected from a single foam vessel at a central location. This means significant savings in relation to the foam supply; however, it is also necessary to build a pipe network connecting the central foam vessel to each storage tank.

The cost of installation (CAPEX-PiFoam) for our most basic system comes to USD 165,000 per tank, or USD 3.3 million for the entire tank park.

Pi Foam CAPEX



Pi Foam OPEX



Maintenance is incredibly simple. The system monitors its own pressure and sends a signal if it detects a problem. Otherwise, the only maintenance required is performing regular functionality **tests on the valve and taking an annual foam sample** to check for proper consistency. These costs come to less than USD 30,000 a year for 20 years altogether, which can be rounded up to USD 600,000 for a 20-year period. So the total budget for protecting our theoretical tank park with the Pi Foam System would come to **USD 3.9 million over 20 years**.

Since this system offers the lowest installation and maintenance costs of all the systems in our study, the time required for an investor to **break even** is also very advantageous – **just seven (7) years**.

USD 3.9 million over 20 years	**Break even** in 7 years

For the sake of simplicity, our study does not consider the time-value of money (interest). It also does not consider insurance premiums or their role in mitigating the cost of fire damage. Insurance premiums are calculated in a manner that guarantees that the insurer will eventually come out ahead, so statistically, insurance payouts do not improve the return-on-investment indicators.

We also did not consider the fact that firefighters who use traditional mobile or semi-stable systems may require **several hours of preparation** before they can begin extinguishing a fire; facility operators must pay for additional measures aimed at **preventing a blaze from spreading** during this pre-extinguishment period (e.g. water-spray cooling for fixed or mobile systems, thermal insulation for storage tanks). Moreover, we did not consider the **significant damages wrought by fire during the preparation period**, not to mention the heat exposure. In these respects, we erred on the side of our competitors.

Summary

Best price-value option would be the Pi Foam System's instant-reaction capabilities (no preparation time required) combined with keeping a smaller-capacity mobile fire brigade at the ready.

We are aware that **every system is unique.** The above calculations were prepared only for purposes of **comparison** and our calculations use prices for the simplest, **most budget-friendly systems** with a favorable arrangement of combustible-liquid tanks. In reality, the systems that protect storage tanks and other installations are much more complicated; we generalized for the sake of simplicity and comparability.

At the same time, **our calculations examined every factor** down the most minute detail. We would be happy to share our data with all interested parties who would like to learn more about our methods.

We believe the most important lesson is that it is always worthwhile to thoroughly evaluate a firefighting system from a professional and financial standpoint, even if it appears to be the most expensive at first glance. This is especially true when discussing a technology **as efficient and low-maintenance as the Pi Foam System**. For those who would argue that a fixed-extinguishment system cannot respond to all types of fire events (a problem that we believe can be resolved through proper design), we suggest that the best price-value option would be the **Pi Foam System**'s instant-reaction capabilities (no preparation time required) combined with keeping a smaller-capacity mobile fire brigade at the ready.

		Mobile	Semi-stable	Trad. stable	Pi Foam System
		Normal fire-vehicle system with water tank and foam monitor	Semi-stable firefighting system with water/foam source	Automatic pump and foam generator-type extinguishment system	Tank-type pneumatic detector-activated Pi Foam System
Time until extinguishment starts		30 - 120 min	15-30 min	3-5 min	0.5 - 1 min
Damage before extinguishment starts		heat stress and deformation on the upper side of the tank wall	heat stress and deformation on the upper side of the tank wall	low scale	not expected
Usual foam-solution intensity (L/min/m2)		5 - 10	5 - 8	5 - 12	15 - 50+
Typical extinguishment time		2 - 48 hours	1 - 24 hours	30 min	2-3 min
Overall damage		severe damage to the tank, usually needs to be demolished	large-scale damage, high repair cost or demolish	low scale damage	low scale or no damage
Extinguisment cost		very high	high	low	low
DEPENDENCIES	Special staff requirement	very high	high	not required	not required
	Roads, traffic	yes	yes	no	no
	Fuel	yes	yes	yes	no
	Electricity	no	yes	yes	no
OPERATIONAL RELIABILITY	Operational Reliability level	high	low	moderate	very high
	Variables that affect operational reliability; potential pitfalls	Condition of fire vehicles and their equipment, traffic, fire brigade skill and training levels, access to water, availability of fire engines, availability of foam concentrate	Condition of fire vehicles and their equipment, traffic, fire brigade skill and training levels, condition of water pumps, access to water, availability of fire engines, availability of foam concentrate, maintenance failure	Electric power supply, condition of pumps, foam mixer, foam concentrate supply, maintenance failure	Mechanical damage, maintenance failure
EXTINGUISHMENT RELIABILITY	Extinguishment Reliability level	low	moderate	moderate	very high
	Variables that affect extinguishment reliability; potential pitfalls	foam, fuel or water supplies run out, updraft, wind or long extinguishment distance	foam, fuel or water supplies run out	expired or poor-quality foam concentrate, capacity limitations	expired or poor-quality foam concentrate
ECONOMIC COMPARISION	CAPEX	moderate	moderate	high	low/moderate
	OPEX	extremely high	extremely high	high	low
	Maintenance requirement	high	moderate	high	low